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Address correspondence to: Marine Fisheries Review, NMFS Scientific Publications Staff, Room 450, 1107 N.E. 45th St., Seattle, WA 98105.

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Marine Fisheries Review

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MFR PAPER 1160

Assessment of North Pacific Stocks of Whales

MICHAEL F. TILLMAN

INTRODUCTION

A large proportion of the American public is familiar with the history of the intensive whale fishery and subsequent depletion of these marine mammals in the Antarctic. Few people are aware, however, that there has also been a rather intensive fishery on whales in the north Pacific Ocean (Fig. 1). In fact, catches of whales from the north Pacific in 1969-70 almost doubled catches from the Antarctic, and from about 1963 until the "discovery" of the Antarctic stock of minke whales in 1972, the north Pacific provided the major share of the world's total annual catch of whales.

The main international body concerned with whaling is the International Whaling Commission (IWC), which was established under terms of the International Whaling Convention of 1946. It 1) carries out research on whales; 2) adopts regulations for protecting stocks by establishing protected species, by fixing size limits for each species, and by closing seasons and areas; and 3) establishes time, method, and intensity of whaling (including the maximum catch of each species to be taken in any one season). Its activities cover all waters in which whaling is carried out by factory ships, land stations, and whale catchers under the jurisdiction of IWC members—including the "North Pacific Rim" governments of Canada, Japan, the United States, and the USSR.

During its heyday in the late 1960's, the north Pacific whale fishery shared many of the characteristics of its well-publicized Antarctic counterpart. That is, following the introduction of Japanese and USSR factory ships into the north Pacific, the catches were characterized by a shift in emphasis to less valuable, smaller species of whales (Bryde's and sei whales) as larger ones (blue and fin whales) became depleted. (The sizes of north Pacific whales are compared in Table 1.)

Since 1974, the Marine Mammal Division of the National Marine Fisheries Service's Northwest Fisheries Center has expanded its studies of population dynamics to evaluate the status of the north Pacific stocks of fin, sei, and sperm whales. The goal of this program has been to provide stock assessments, independent of Japan and the USSR, to IWC for its use in developing rational measures for management of these valuable resources. The following report reviews the status of whales and whaling in the north Pacific and summarizes some recent results concerning assessment of the north Pacific sei whale—a stock of primary concern at this time.

Michael F. Tillman is with the Northwest Fisheries Center, National Marine Fisheries Service, NOAA, 2725 Montlake Boulevard East, Seattle, WA 98112.

MODERN WHALING IN THE NORTH PACIFIC

Prior to and immediately after World War II (1941-45), whaling in the north Pacific was conducted primarily by catcher boats from land stations in Canada, Japan, the United States, and the USSR. These operations were highly efficient on nearshore species in that they may have caused the extinction of one stock—the Asiatic stock of the gray whale—and the need to protect two others—the black right whale in 1937 and the American stock of the gray whale in 1947. A third nearshore species, the humpback whale, was also intensively harvested by land-based boats.

United States participation in the post-war phase of these land-based operations was never very extensive. According to Rice (1971)[1], only six vessels operated from three shore stations between 1956, when U.S. whaling

[1]Rice, D.W. 1971. Whales and whale research in the Eastern North Pacific. Conf. on Biol. of Whales, U.S. Int. Biol. Prog. Luray, Va., June 1971, 35 p. (Processed.)

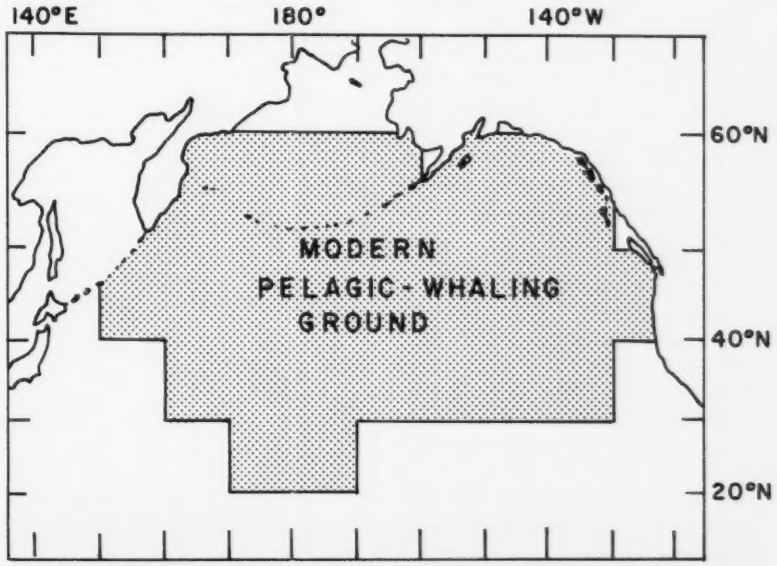

Figure 1.—The north Pacific whaling ground. Japanese land-based operations also operate north of lat. 20°N and as far west as long. 160°E.

Table 1.—Sizes of north Pacific species of whales.[1]

Group and species of whale	Max. length (m)	Av. length (m)		Max. wt (metric tons)
		Males	Females	
Baleen:				
Black right	18			
Blue	30		25	165
Bryde's	14			
Fin	24	18	20	
Gray	15	13	14	30
Humpback	15	12	14	
Minke	10		8	10
Sei	19		15	
Toothed:				
Sperm	20	15		50

[1] North Pacific whales are on the average smaller than their counterparts that are taken in the Antarctic.

began, and 1972, when commercial whaling was no longer permitted under U.S. law. The greatest catch for any of those years (excluding gray whales taken for scientific purposes) was 338 whales in 1961. By comparison, the greatest Japanese land-based catch during the same period was 4,777 whales in 1968. United States catches during this period consisted mainly of fin, sei, humpback, and sperm whales.

The modern era of pelagic (i.e., open-sea) whaling in the north Pacific began with a single factory ship operating off Asia in 1952. During 1954-61, only three factory ships operated, but this type of whaling was extended eastward to the American side of the north Pacific. Then, in 1963 the arrival of seven factory ships from Japan and the USSR on north Pacific whaling grounds signaled the expansion that later took place as this area began to absorb the excess whaling equipment made available by the complete protection of Antarctic blue whales and by the setting of stringent quotas upon other Antarctic species.

Considering the historical development of north Pacific whaling with respect to baleen whales (species of whales are conveniently divided into two main groups—baleen whales and toothed whales), pelagic whalers in the north Pacific concentrated upon the humpback whale in the early 1960's (Fig. 2). Blue whales were also taken in the early days but never were an important constituent of the fishery. During the mid-1960's, fin whales then became the major species of interest, while during the late 1960's and early 1970's, the sei whale became the mainstay of the fishery. Unfortunately, the familiar pattern of shifting emphasis from one baleen whale species to another seems to be occurring again with the recent "discovery" of major concentrations of Bryde's whales south of lat. 35° N.

Considering the toothed whales, the sperm whale has been the most important species of this group taken commercially throughout all of the world's oceans. In the north Pacific this species has consistently been the major constituent of the total catch of whales during the 1960's and 1970's. Currently, the fishery takes 8-10 thousand sperm whales compared with 2-3 thousand baleen whales.

CURRENT STATUS OF NORTH PACIFIC STOCKS

As previously noted, the gray whale and black right whale were the first species totally protected in the north Pacific. This action may have been too late for the Asiatic stock of gray whales, but the American stock has since recovered, achieving a stable size of 11,000 animals. This number is thought to be near the original population size (in this article, the term "original population" refers to the size prior to the modern land-station and factory-ship fisheries). The black right whale, on the other hand, has not been so fortunate, and its population still remains depressed—with numbers fluctuating near 200 individuals.

Alarmed by assessments submitted by the North Pacific Working Group (a subcommittee of the IWC Scientific Committee), the IWC in 1966 extended protection to the north Pacific stocks of blue and humpback whales. The blue whale had declined to 1,500 animals from an original population of about 5,000. Based upon population estimates (determined from sighting records) that have been made since then, this stock apparently still remains depressed. On the other hand, the same sighting records indicate that the humpback's situation recently may have improved. However, this stock still numbers only a few hundred individuals, whereas the size of its original population, although not specifically known, must have been in the thousands.

Currently, of the large whales, the IWC allows only fin, sei, Bryde's, and sperm whales to be harvested in the north Pacific. Stock sizes as determined by the IWC Scientific Committee for

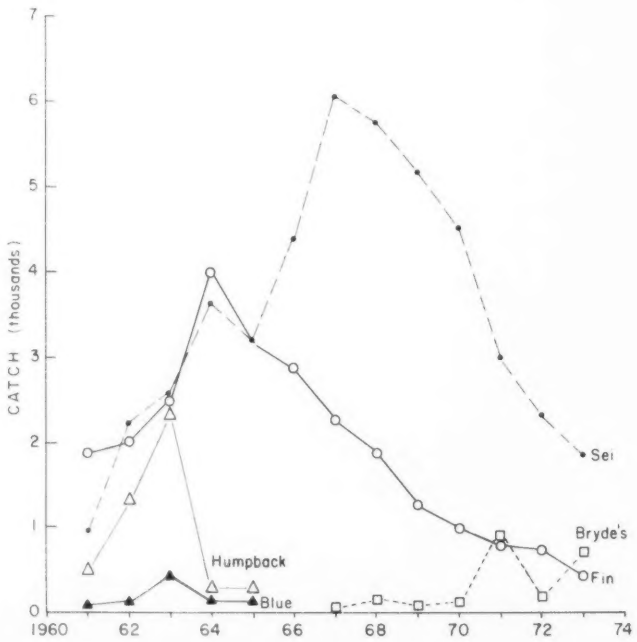

Figure 2.—Similar to Antarctic baleen whales, north Pacific catches demonstrate a marked shift from one major species to another.

three of these species are given in Table 2. Only the sperm and Bryde's whales seem to be in good condition, having current stock sizes in excess of those numbers of whales at which Maximum Sustainable Yield (MSY) occurs. The Bryde's whale is a newcomer to the fishery, and its current stock size is probably near the size of the original population. The fin whale, on the other hand, is now 37 percent below its MSY level, and some members of the IWC Scientific Committee believe there are substantial reasons to set a zero quota on this stock.

Table 2.—Stock size in numbers for three north Pacific species of whales.

Species	Original population	MSY[1] level	Current population
Fin	44,000	27,000	17,000
Bryde's	Unknown	10-15,000	20-30,000
Sperm:			
Male	166,000	58,000	72,000
Female	152,000	79,000	125,000

[1]Maximum sustainable yield.

RECENT RESEARCH ON NORTH PACIFIC SEI WHALES

Determining the status of the north Pacific sei whale has lately been a major concern of the Marine Mammal Division. Up until the June 1974 meeting of the IWC, assessments of this stock had been quite optimistic. However, the Japanese scientists presented new evidence at that meeting which indicated a continuing decline in numbers (Fig. 3). Consequently the Scientific Committee feared that the north Pacific sei whale had fallen below its MSY level.

Analysis of the population dynamics of this stock has shown that the Scientific Committee's fears were justified. A method for estimating stock size has been developed, based upon Chapman's (1974) model for Antarctic sei whales. In this model, indices of north Pacific sei whale abundance over a series of years have been related to cumulative stock removals caused by harvesting and natural mortality and to cumulative additions due to recruitment. The model gives an estimate of stock size for the beginning year of data. This estimate is extrapolated backward and then forward to estimate, respectively, the size of the original and current populations: original population, 50,000; MSY level, 28-29,000; current population, 20,600.

Since it is now 26-29 percent below its MSY level, the north Pacific sei whale apparently has undergone a considerable decline due to exploitation. Considerable restraint is, therefore, urged when setting future quotas. To ensure that the stock rebuilds, the model suggests that such quotas be less than the current replacement yield of 1,870 whales.

IWC ACTION ON PROPOSED WHALING MORATORIUM

Based upon similar evidence of continuing declines in stock sizes, conservationists have advocated the adoption of a 10-year moratorium on all commercial whaling. The IWC rejected this "blanket" moratorium in 1972-73, but in 1974, did agree in principle to adopt an Australian proposal for a partial or "selective" moratorium. This latter moratorium was to be applied to those stocks which, in the estimation of the Scientific Committee, had fallen below levels that produce a reasonable yield (be that MSY or some other optimum yield). The Scientific Committee, subsequently, was asked to meet in December 1974 to define the criteria for designating the following categories of stocks: protection; sustained management; and initial management. It was also asked to advise the IWC on the allocation of whale stocks to these categories.

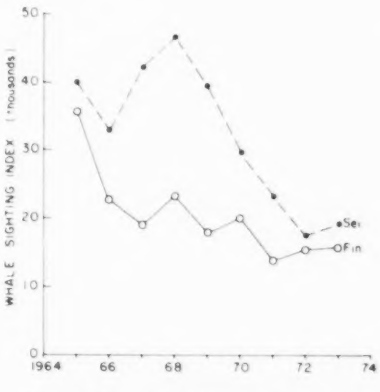

Figure 3.—Systematic sightings of whales from scouting vessels have proven to be useful and reliable indicators of stock abundance for north Pacific fin and sei whales. Such data indicating marked declines in stock sizes have alarmed conservationists throughout the world.

The Scientific Committee met as directed in La Jolla, Calif., and, with the exception of the Japanese scientists, agreed to the following approach for defining categories:[2]

> Protection Stocks—Current population size falls below the lower limit of Sustained Management Stock; i.e., more than 10 percent below the MSY level. A harvest will not be allowed.
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Figure 4 graphically depicts these proposed criteria, utilizing the framework of a typical yield curve. Under this scheme, a stock would become protected if its current size fell below the estimated MSY level by 10 percent of that MSY level. That is, for an MSY level of 50,000 whales, a stock would become a Protection Stock if its currently estimated size fell below 45,000 animals.

Using these criteria, the Scientific Committee has designated the north Pacific fin and sei whale as Protection Stocks and the sperm and Bryde's whale as Initial Management Stocks. This allocation was confirmed at the June 1975 IWC meeting.

FUTURE RESEARCH NEEDS

During the special December meeting of the IWC Scientific Committee at La Jolla, Calif., new biological data were made available which indicated a need for revising the sei whale model. Apparently, mean ages at recruitment and at maturity for this stock have decreased in response to exploitation; i.e., sei whales are maturing and entering

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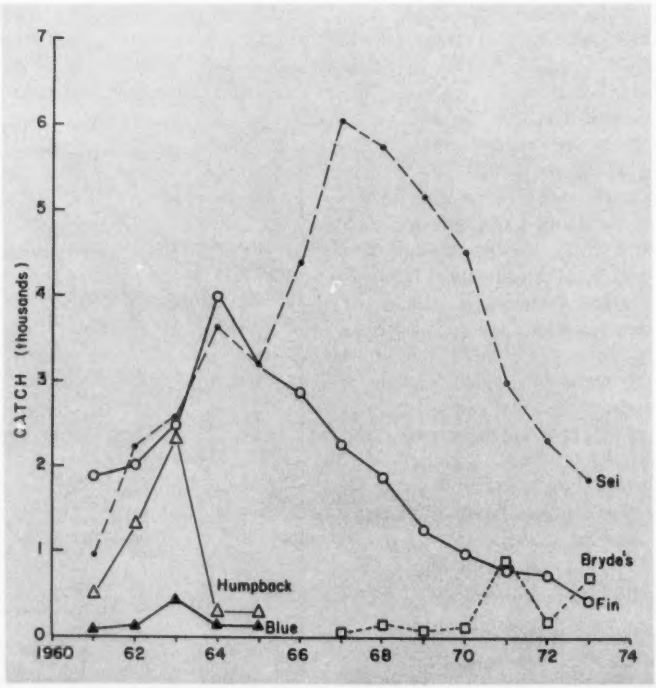

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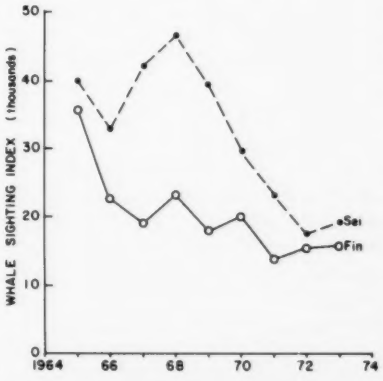

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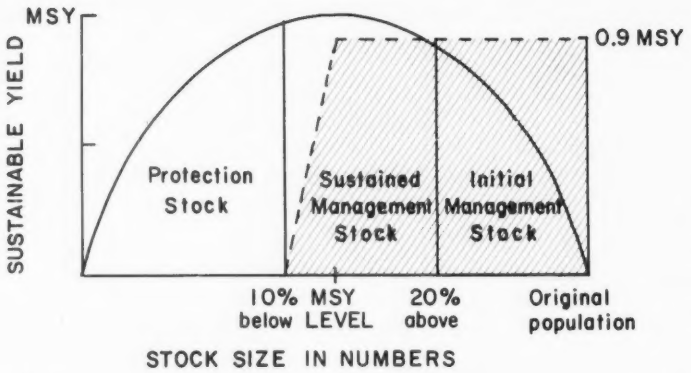

Figure 4.—Criteria for defining categories of whale stocks as proposed by the IWC Scientific Committee. The shaded area indicates the maximum catches permitted for the two harvestable categories.

the exploitable portion of the stock at ages younger than those found prior to heavy exploitation. Consequently, the assumption that recruitment into the stock is constant may no longer be valid, particularly during the later years of exploitation.

Research is currently underway at the Northwest Fisheries Center to ascertain the degree and direction of change, if any, in sei whale recruitment. Variation in recruitment numbers will be determined using Allen's (1966) technique for estimating annual recruitment from age composition data. If the assumption of constant recruitment proves to be invalid, these estimated recruitment numbers will then be used to prepare new estimates of initial and current sei whale abundance.

The Marine Mammal Division has identified several other problems as subjects for future research:

1. Determining the shape of yield curves applicable to whales. These curves are likely skewed to the left (have the left-hand tail drawn out) but data are lacking to demonstrate this for most species. Knowing the shape of these curves is critical since the criteria for defining categories of stocks are couched in terms of nearness to the MSY level.

2. Accounting for growth of sperm whales in assessment models. The average size of sperm whales has decreased drastically in the past 20 years (from 45 to 28 tons). Use of a biomass criterion, MSY (weight) instead of MSY (numbers), would account for such size changes and result in stock sizes larger than those currently in existence.

3. Correcting for bias in catch-effort statistics. Many scientists and managers have criticized currently used indices of stock abundance but few have indicated what to do to correct for bias. Of particular concern is the multispecies problem, i.e., the shifting of emphasis from one species to another with time.

Resolution of these problems would significantly aid the IWC in its development of rational measures for managing the north Pacific stocks of whales.

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MFR PAPER 1161

Forecasts of Atlantic and Gulf Menhaden Catches Based on the Historical Relation of Catch and Fishing Effort

WILLIAM E. SCHAAF, JAMES E. SYKES, and ROBERT B. CHAPOTON

ABSTRACT—Forecasts of the annual purse seine catches in 1973 and 1974 of the Atlantic menhaden, Brevoortia tyrannus, *and Gulf menhaden,* B. patronus, *were made using multiple regression equations of catch in a given year on catch and effort in the previous year. Anticipated coefficients for the equations were estimated from effort for the given year, 16 years of data for the Atlantic fishery and 27 years for the Gulf. We applied this technique to all age classes combined. For the Atlantic fishery, the equation accounted for 85 percent of the variation in catches. The coefficient of determination for the Gulf fishery was 86 percent. Observed Atlantic catches deviated from the forecasts by 9 percent in 1973 and 22 percent in 1974. The errors for the Gulf were 2 percent in 1973 and 1 percent in 1974.*

When used to estimate historical catches, the equations were fairly accurate, but such empirical methods cannot substitute for an understanding of a causal mechanism determining population dynamics. Even though the average error may be quite small, the error for a specific year can be large.

INTRODUCTION

We prepared a method of forecasting seasonal purse seine catches of Atlantic menhaden, *Brevoortia tyrannus*, and Gulf menhaden, *B. patronus*, from catch and effort data. If a forecast of the annual catch were available, the fishing industry would be able to plan its operations for the coming year more efficiently. If the significance of the functional relations between catch and effort were determined, biologists would be able to build structural mathematical models (Graham, 1935, 1939; Schaefer, 1954, 1957; Schaaf and Huntsman, 1972). The success of man's continuing efforts to obtain greater harvests of marine organisms will depend on his ability to comprehend and predict the consequences of exploitation.

There are few published papers on forecasting of catches. Several papers that were presented recently at a symposium on forecasting in the USSR, discussed mainly the methods of determining the relative size of fish populations according to their rate of decrease (Dement'eva and Zemskaya, 1967). Instead of forecasting catches they established, for the most part, only trends in changes of the resource. Sette (1931, 1932, 1933, 1934) made forecasts of the Atlantic mackerel catches after examining age-class composition. Royce and Schuck (1954) made forecasts of haddock catches on Georges Bank by relating catch and effort of different age classes in a multiple regression equation. Schaefer (1954, 1957) and Shimada and Schaefer (1956) discussed the theoretical and future abundance of tuna in the Pacific, but attempted no actual forecasts of catches. Watt (1956) presented a summary of methods commonly used in prediction models. Forecasting sockeye salmon runs and their economic consequences to Bristol Bay, Alaska, was discussed by Mathews (1967). Frequent attempts, exemplified by Manthey (1972), were made to forecast Pacific salmon runs in certain rivers or river systems. Most of those forecasts were based on correlations between the index of escapement of juveniles and their estimated numbers when they returned to spawn.

Because menhaden processors have always been concerned about fluctuations in landings, development of methods to forecast seasonal abundance has been considered since studies began in the 1950's. Before forecasting could be attempted basic information about the fishery and the biology of menhaden has to be compiled. This information dealt with such problems as population structure and size, life cycles, distribution, movement, and age and size composition of the catches. By 1960 biologists had learned enough to make tentative statements about future seasonal abundance to members of the industry and their annual meetings, although they made no quantitative forecasts of catches. Such forecasts could not be made accurately until the relation between catch and effort was determined. We have explored that relation, and have established a basis for forecasting catches of Atlantic and Gulf menhaden.

William E. Schaaf, James E. Sykes, and Robert B. Chapoton are with the Atlantic Estuarine Fisheries Center, National Marine Fisheries Service, NOAA, Beaufort, NC 28516.

ATLANTIC MENHADEN FISHERY

Description of the Fishery

Federal biologists began studies in 1955 on the population dynamics of Atlantic menhaden that resulted in three findings pertinent to forecasting the catch: 1) the existence of a single population; 2) the gradual trends in catches rather than abrupt annual changes; and 3) the complex, stratified distribution along the coast by age and size. The first two simplify forecasting and the third complicates it.

As a single population, Atlantic menhaden occur from central Florida to the Gulf of Maine and are exploited throughout their entire range. Adults occur in inshore ocean waters and the larger bays and sounds and juveniles are found mainly in estuaries. Some fish live 10 years, but most do not live past seven. Although fish of all ages are subject to exploitation, most of those caught are from 1 to 3 years old.

Catches of Atlantic menhaden increased steadily through the mid-1950's, decreased in the mid-1960's, and then increased again in the early 1970's. As the fishery expanded following World War II, new plants and vessels were added, old vessels were modernized, and methods of locating, handling, and processing fish were improved. The catch rose from 296,000 metric tons in 1945 to 712,000 in 1956. A decline in catches began in the northern part of the fishery in the late 1950's and in the southern part in the early 1960's. By 1969 the catch had dropped to 161,000 metric tons. By 1972 it increased to 363,000 but decreased again in 1973 and 1974. Variations in the catches from one year to the next have been small relative to the historical range of catches.

From late spring until early autumn, adult Atlantic menhaden are distributed by age and size along the coast (Nicholson, 1971b, 1972). Age 1 fish are the most abundant age groups south of Cape Hatteras, although age 2 fish constitute up to 40 percent of the catch in some years. Age 1 and 2 fish are the most abundant age groups in Chesapeake Bay and coastal waters from Cape Charles, Va., to Delaware Bay. They are larger than fish of the same age south of Cape Hatteras. Age 2 fish are the most abundant age group in waters off New Jersey. Age 3 and 4 fish are most abundant in Long Island and Nantucket Sounds, while age 4 and older fish are dominant north of Cape Cod. Because of northward migrations in early spring, the slow northward movement during the summer, and southward migrations in autumn, the proportion of each age group in any area will change from time to time.

Estimation of Atlantic Catches in Previous Years

After examining the relation for past years between catch and effort, we found that a multiple regression equation employing these variables estimated annual catch more reliably than other methods we tried. As a unit of fishing effort we used the vessel week, which is one vessel fishing one calendar week (Nicholson, 1971a). Total effort is the sum of the number of weeks for all vessels.

Estimated catches for past years, or hindcasts, have been calculated by a multiple regression equation: $C_{n+1} = a + b_1 (E_n) + b_2 (C_n) + b_3 (E_{n+1})$,

where C_{n+1} = estimated catch in year $n+1$,

C_n = estimated catch in year n,

E_n = estimated fishing effort in year n, and

E_{n+1} = estimated fishing effort in year $n+1$.

The coefficients a, b_1, b_2, and b_3 are average values that are calculated mathematically from known values of catch and effort for the period 1955-72. They are not interpreted biologically. By substituting known values from our records for the independent variables, we estimated a catch for each year and compared it to the actual catch. The degree of association between the dependent and independent variables was measured by the multiple correlation coefficient (R). The percentage of variation in catches explained by the independent variables is measured by the square of the coefficient of determination (R^2).

The R^2 value showing variation in catch estimates associated with the

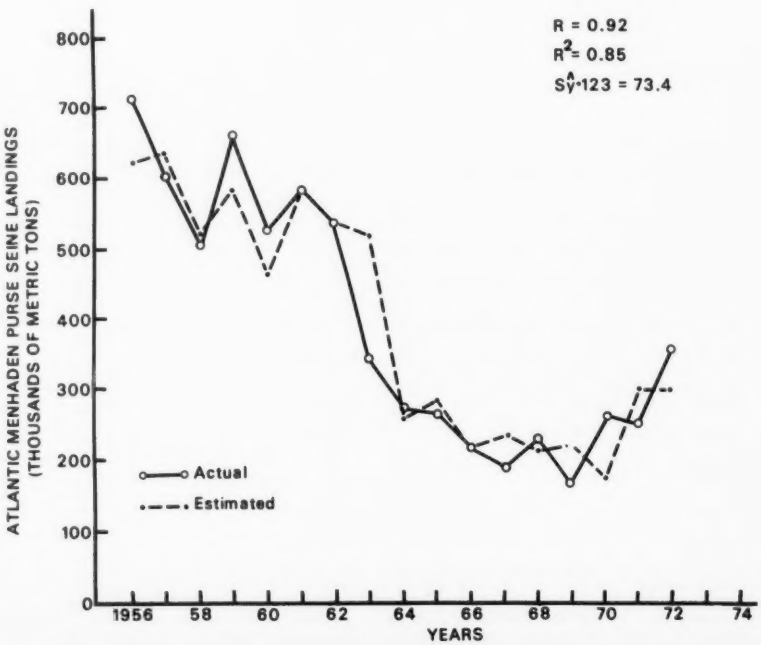

Figure 1.—Actual and predicted landings of Atlantic menhaden in thousands of metric tons by multiple regression, 1956-1972.

independent variables, was 85 percent. The agreement between actual and estimated catches was considered satisfactory for accomplishing our immediate forecasting needs (Fig. 1). The equation does not predict sudden and large changes in catch, however, such as in 1963, when the exceptionally large 1958 year class ceased to contribute substantially to the fishery. In that year the equation overestimated the catch by 50 percent. Since there is close agreement in most years between estimated and actual catches, the equation can be used to predict total catch on the Atlantic Coast.

Forecasts of 1973 and 1974 Atlantic Catches

Because we did not know exactly how much fishing effort there would be in the forecast year, we based our estimates on percentages of effort in the previous year. Estimates at various percentages of effort in the year prior to the forecast year are shown in Table 1. Advance information from industry provides a preliminary estimate of effort for the coming year. Our forecast of the Atlantic menhaden catch in the 1973 fishing season was 402,000 metric tons with a 10 percent increase over 1972 effort. Eighty percent confidence limits ranged from 308,000 to 496,000. The forecast for the 1974 fishing season was 352,000 metric tons with no change in effort. Eighty percent confidence limits ranged from 301,000 to 402,000.

Table 1.—Estimated catch of Atlantic menhaden and number of vessel weeks in the forecast years 1973 and 1974 based on varying percentages of fishing effort in 1972 and 1973.

Percent of effort	No. of vessel weeks	Forecast catch	Actual catch
1972		*metric tons* 1973	*metric tons*
+10	1,020	402,000	
[1]+ **8**	**1,000**	**382,000**	347,000
No change	927	381,000	
−10	834	360,000	
1973		1974	
+10	1,100	357,000	
[1]+ **5**	**1,050**	**360,000**	295,000
No change	1,000	352,000	
−10	900	329,000	

[1]Boldface numbers are estimates from actual percent of fishing effort in previous year.

The observed catch of 347,000 metric tons in 1973 was 14 percent less than predicted, but within the 80 percent confidence limits. Fishing effort however was 1,000 vessel weeks, 20 vessel weeks less than expected. If the correct amount of effort had been anticipated, the catch forecast would have been 382,000 metric tons, or 9 percent greater than observed.

The forecast issued for the 1974 fishing season anticipated a catch of 352,000 metric tons with unchanged effort (1,000 vessel weeks) and would have predicted a catch of 360,000 metric tons at a 5 percent increase in effort (1,050 vessel weeks). The observed catch in 1974 of 295,000 metric tons was 22 percent less than forecast and slightly outside the lower 80 percent confidence limit.

GULF MENHADEN FISHERY

Description of the Fishery

As a result of investigations begun on Gulf menhaden by the National Marine Fisheries Service in 1964, data on population structure and catch and effort statistics are available for that fishery. As in the Atlantic menhaden fishery, these data facilitated the development of methods for estimating catches.

One population ranging from southern Florida to Yucatan supports a fishery from Florida to Texas. Although Gulf menhaden may live to be 5 years old, the fishery is supported mainly by age 1 and 2 fish. Some fish are recruited in late summer at age 0 but most are recruited at age 1. There appears to be no extensive coastwise movement of fish by age and size throughout the fishing area. They move out of coastal waters in October and November to offshore areas in the Gulf and return to coastal areas in March and April. Fishing occurs from April to October.

The purse seine fishery began modernizing and expanding after the 1940's when demand for fish meal and oil increased. Expansion was rapid through the 1950's and continued until the mid-1960's. The catch, after increasing from 75,000 metric tons in 1948 to 479,000 tons in 1962, fluctuated between 316,000 and 728,000 from 1964 to 1972, the peak year. Fluctuations in yearly catches are greater than in the Atlantic fishery, as might be expected in a fishery with fewer age groups, although annual variations have been small relative to the historical range of catches.

Estimation of Gulf Catches in Previous Years

The multiple regression equation using catch and effort data is a reliable method of estimating catches in the Gulf fishery. The regression coefficients a, b_1, b_2, and b_3 were calculated from 27 years of records, 1946-72. Fishing effort is measured in vessel-ton weeks, the product of fishing time and the registered net tonnage of a vessel. Since on the average, large vessels catch more fish per week than small vessels, the vessel-ton week accounts for some of the differences in efficiency between different size vessels. Therefore, the vessel-ton week measures effort more accurately in the Gulf than a vessel week. The relation between estimated and actual catches is shown in Figure 2.

The agreement between actual and estimated catches for the 27-year period was good, but there was closer agreement in the early years of the fishery, from 1947 to 1956, than in later years (Fig. 2). As effort increased in later years and larger percentages of the available fish were caught, variations in year-class strength probably exerted more influence on the size of the catch. Since age 1 fish normally constitute over half of the weight of the catch, variations in their abundance and average weight have considerable effect on the catch. The greater the variability in the strength of the incoming year classes, the more difficult it is to predict catches accurately especially when using only historical catch/effort relationships.

Forecasts of 1973 and 1974 Gulf Catches

As with the Atlantic fishery, we did not know how much effort there would be in the forecast year so we based our forecasts on effort of the preceding year, plus or minus 10 percent of the earlier effort (Table 2). Our forecast of the Gulf menhaden catch in the 1973 fishing season was 466,000 metric tons with a 10 percent reduction from 1972 fishing effort. Eighty percent confidence

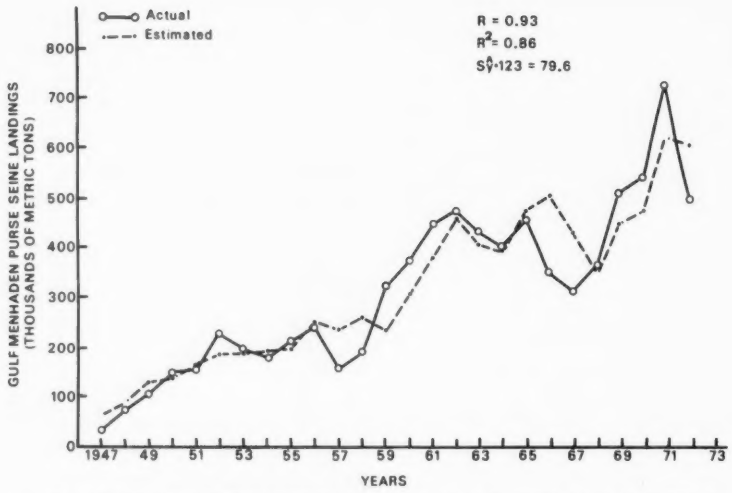

Figure 2.—Actual and predicted landings of Gulf menhaden in thousands of tons by multiple regression, 1947-1972.

limits on this forecast ranged from 404,000 to 528,000. The forecast for the 1974 fishing season was 557,000 metric tons with an increase in effort of 10 percent over observed effort in 1973. Eighty percent confidence limits ranged from 518,000 to 596,000.

The observed catch in 1973 was 486,000 metric tons with 426,000 vessel-ton weeks, a level of effort 5 percent less than in 1972. The catch predicted from only 426,000 vessel-ton weeks would have been 477,000 metric tons, 2 percent less than observed.

The catch forecast for 1974 was 557,000 metric tons at an increase in effort of 10 percent (469,000 vessel-ton weeks). Fishing effort actually increased 14 percent to 485,000 vessel-ton weeks and, if predicted accurately, our model would have estimated a catch of 584,000 metric tons, 1 percent less than the observed catch of 587,000 metric tons.

Table 2.—Estimated catch of Gulf menhaden and number of vessel-ton weeks in the forecast years 1973 and 1974 based on varying percentages of fishing effort in 1972 and 1973.

Percent of effort	No. of vessel-ton weeks	Forecast catch	Actual catch
		metric tons	*metric tons*
1972		1973	
+10	492,000	600,000	
No change	447,000	533,000	
[1]– 5	**426,000**	**477,000**	486,000
–10	402,000	466,000	
1973		1974	
[1]+14	**485,000**	**584,000**	587,000
+10	469,000	557,000	
No change	426,000	492,000	
–10	384,000	426,000	

[1]Boldface numbers are estimates from actual percent of fishing effort in previous year.

SUMMARY

We have applied a method of predicting the total catch one year in the future for both the Atlantic and Gulf menhaden purse seine fisheries by considering an empirical relation between the total catch and the total effort. This method is usually applied to specific age classes in the fishery, where the logic of assuming that the catch depends on last year's catch and effort, as well as on current effort, is perhaps more reasonable. We used total catch, however, because 1) for the Atlantic fishery it is difficult to prorate effort on different ages, and 2) for the Gulf, aging is more uncertain; but there are fewer age classes in the fishery. In statistical studies of this sort many other models, of course, are conceivable and cannot be discarded a priori. It was not our intent to study the possibilities exhaustively, but to confine ourselves to fairly standard approaches that gave consistently reliable results for both fisheries. The multiple regression we used of C_{n+1} on C_n, E_n, and E_{n+1} accounted for 85 percent of the variance in Atlantic catches and 86 percent in Gulf catches. This model could be refined perhaps by the inclusion of more variables; gains in R^2 would have to be carefully evaluated against possible loss of precision with the fewer associated degrees of freedom. We present this work as a progress report and do not intend to stop considering alternative models. Forecasts might be more useful to the fishing industry, however, if they were more specific, perhaps by plant or port, even with less precision.

Useful as this type of forecast may be to industry, fishery biologists view it as a point in the continuum of understanding the dynamics of the resource under exploitation. Understanding and predicting deviations from average expected trends, presumably caused by variation in the number of young fish entering the fishery, requires more knowledge of the biology of recruitment. A measure of the incoming year class would permit development of short-term fishing strategies to take advantage of exceptional year classes or to prevent overexploitation of weak year classes. Forecasting recruitment is difficult and usually costly, but studies of this problem are in progress at the Atlantic Estuarine Fisheries Center, Beaufort, N.C. (Nelson et al.[1]). We will require structural mathematical models of the dynamics of a fish population in order to predict long-term consequences of various rates of exploitation and to achieve optimum yields. Our knowledge of the Atlantic menhaden fishery has progressed to the point where we have begun this type of modeling (Schaaf and Huntsman, 1972).

ACKNOWLEDGMENTS

We acknowledge the late David W. Frame for his enthusiastic response during the initiation of these studies; his accidental death prevented him from pursuing them to this point. We thank David R. Colby and Robert M. Lewis for aid in performing many computer analyses. William R. Nicholson provided much critical thinking and editorial expertise to earlier attempts at describing the study.

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MFR PAPER 1162

Popular in Europe, the blue mussel awaits discovery by the American public.

Blue Gold: Mariculture of the Edible Blue Mussel (*Mytilus edulis*)

C. GRAHAM HURLBURT and SARAH W. HURLBURT

INTRODUCTION

Mytilus edulis, commonly called the blue, or edible, mussel, is found in great abundance, growing wild, along the northern coast of the United States and Canada. This most desirable shellfish is almost unutilized in North America. Yet in Europe, where it is both a mainstay of life and a gourmet food, it is so popular that it is "farmed" commercially and the demand is greater than the supply. It is the same general size and shape of a soft-shelled (steamer) clam, but dark blue or brownish in color. It grows like an oyster; that is, not in the sand or mud but rather in clumps directly exposed to the ocean tides. The taste is a blend between an oyster and a clam, but, many say, better than both. The mussel is as rich in protein as T-bone steak, low in fat, an excellent source of minerals and vitamins, and can be eaten raw or prepared more than 100 different ways. Now that clams, oysters, lobsters, and finfish (as well as fishing employment) are becoming depleted in the United States, Americans will start to pay more attention to this delectable ocean food.

The mussel is a mollusk with two equal shells. The inside lining of these shells is pearly and iridescent. It is perfectly adapted to its tidal environment which explains why it is the most successful and abundant bivalve along the northern coasts. One of the major secrets to this success is its ability to attach itself to almost anything with its byssus. This attachment is so firmly moored that it can withstand the heaviest storm sea action. The mussel, like other bivalves, is a filter feeder. Its protective shells are tightly closed if exposed at low tide, but when covered with water they are held slightly open to allow the water to be drawn through the animal. It flows through the gills for respiration, and the food in the form of plankton (animal and vegetable organisms) and detritus (fine organic debris) is filtered into the mouth.

Enormous quantities of water pass through every mussel. An adult about 3 inches long will pass through itself as much as 10-15 gallons in a 24-hour period. An acre of wild mussels containing 2,000 bushels represents an astounding filtering machine. The apparently infinite supply of plankton organisms and detritus provides an almost inexhaustible supply of primary food which is rapidly and efficiently converted by the mussels to excellent flesh for human consumption.

This filter feeding explains why at infrequent times and in certain locations mussels should not be eaten. They and other bivalves can accumulate toxic substances when present in the water around the mollusks. Monitoring of the shellfish areas will prevent human consumption when accumulation rises above safe levels. Depuration (placing in sterilized sea water to remove bacterial substances) can similarly be implemented.

In northeast United States and Canada mussels spawn from April to Sep-

C. Graham Hurlburt is Director, Administrative Services, Harvard University, Holyoke Center, Cambridge, MA 02138. He was the first participant in the University's Administrative Year of Study (AYS) program under which this study was accomplished in Europe in 1973-74. Sarah W. Hurlburt is an author and photographer. The authors have an avocational interest in mussel culture and the aim of their study was to stimulate worldwide interest in the production and use of the blue mussel. The report upon which this paper is based was presented at the Annual Meeting of the Society for the Advancement of Food Service Research in Chicago, Ill., 1 November 1974.

Mussel culture ropes, Duxbury, Mass. C. G. Hurlburt photo.

Workers wrapping mussels on ropes, Bay of Arosa, Spain. C. G. Hurlburt photo.

tember, and they are extremely fecund. The sexes are separate. The female sets adrift up to 25 million eggs at a single time. The males immediately release their sperm and the eggs are fertilized as they drift. When a great number of animals do this simultaneously, the surrounding water will appear milky. After fertilization, growth is extremely rapid. The young mussel passes through the swimming phase, maturing to the adult form rapidly. They settle down close together by attachment to objects and each other with their byssus. Their growth is very fast making them ideally suited to various culture techniques.

Why, then, don't Americans eat mussels? Their consumption in the United States is limited to a few gourmet restaurants and recent immigrants from Europe. The pilgrims in Plymouth recognized their value and it was stated by Governor William Bradford in 1622: "This bay (Plymouth, Duxbury, Kingston) is a most hopeful place. . .an abundance of muscels, the greatest and best we ever saw; . . ."

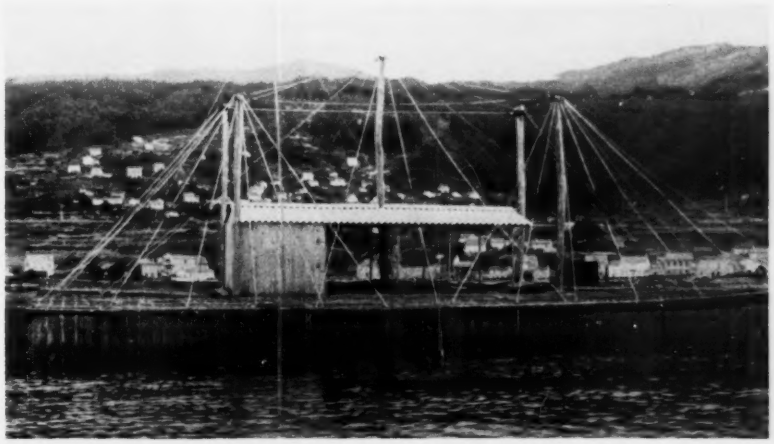
Most Americans have not been exposed to this seafood, probably because until recently other shellfish and finfish have been plentiful and inexpensive; but this is no longer the case. Over 80 percent of the fish purchased in the United States today is imported. Perhaps the name "mussel" is not pleasing to some.

Mariculture is the scientific term for "farming or cultivating the sea." Is a cultivated mussel better than a wild one? Probably yes, although they taste similar. Why? Because under controlled conditions they grow faster, can be harvested when they are fattest, and much more production can be achieved from a limited area of ocean. Cultured mussels are much more standard than wild ones. Also, it is a profitable industry—the fisherman-farmers make money, as well as the dealers, processors, markets, and restaurants.

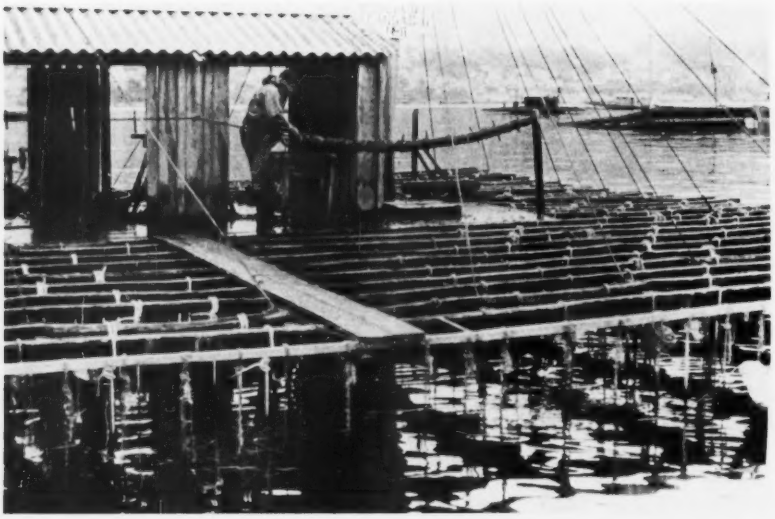
How is mussel mariculture accomplished in Europe and could the same be achieved in North America? To answer the latter first, we are certain that mussels could be farmed in North America just as they are in Europe, both in areas where they now grow wild and in many other waters where they are not now abundant. Problems—yes, but not insurmountable. In Europe they are grown in several different ways, depending on the geography of the coast and the velocity and heights of the tides. We shall describe three principal methods of mussel farming. These methods could be adapted to our coastal areas and the ones used would depend on local geographic and tidal conditions. There are a number of variations, but the three principal methods are: (1) the raft culture of Spain; (2) the pole culture of France; (3) and the bottom culture of The Netherlands.

NORTHWEST SPAIN—RAFT OR ROPE CULTURE IN THE GALICIAN BAYS

On the northwest Atlantic Coast of Spain at about the 42nd parallel lie five bays or rias. They extend far inland and the slope of the land to the water is reasonably steep, not unlike the coast of Maine and Canada. At the extreme they are 15 miles long, from 2 to 6 miles wide, and up to 200 feet deep with an average depth of 90 feet. They are protected from the full



Mussel raft, Bay of Vigo, Spain. C. G. Hurlburt photo.



Fisherman working on mussel raft, Bay of Vigo, Spain. C. G. Hurlburt photo.

Mussel depurator, Bay of Vigo, Spain. C. G. Hurlburt photo.

Processed mussel products, Pontevedra, Spain. C. G. Hurlburt photo.

force of the ocean by islands at their mouths. They have an average tidal rise and fall of about 10-12 feet. The water salinity is about 35 parts per thousand and the annual water temperature at the surface varies between 48° and 70°F. The mussel raft culture in this area is only about 30 years old.

The raft is a rather simple device. The first ones were made from the hulls of old fishing vessels. Later structures have from four to six concrete or steel floats or pontoons and a few new ones are constructed of Styrofoam[1] and fiberglass. On top of these floats is constructed a wooden (eucalyptus) lattice framework of 2-inch square timbers about 18 inches apart to which the ropes are fastened. The overall size of the rafts vary, but an average one might be 75 feet square and would support 700 ropes. The lattice frames are supported by stays running down from masts.

The rafts are anchored along the sides of the bays with large concrete moorings in about 35 feet of water at low tide. Each rope is about 30 feet long so it never touches the bottom. This eliminates the problem of starfish and other bottom predators. In the fall, clumps of young seed mussels (each about 0.25-inch long) are gathered from the rocks along the shore and wrapped upon the ropes with a water soluble rayon netting that dissolves within several days. During this time the mussels have attached themselves by their byssus to the ropes. The ropes are suspended from the rafts. In the spring the young mussel seed collects directly on bare ropes hanging from the rafts for that purpose. The mussels from the autumn seed mature to about

[1]Mention of trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

Mussels on bouchots, Bay of Aiguillon, France. C. G. Hurlburt photo.

3.5-4 inches in one year. These are the largest and fastest commercially-grown mussels in the world. Those from the spring seed take approximately 18 months to mature. The weight yield of meat to total live weight in the shell is 35-50 percent.

The mussels have to be thinned and transplanted several times during the cycle as their fast growth and bulk would cause them to fall off the ropes. The transplantation is accomplished by stripping the mussels off the ropes and winding them onto new ropes with netting or string. In some cases one rope will be stripped and two or three new ropes of mussels are made. The ropes are either 0.5 inch nylon or 1-inch local spart grass—all ropes being tarred. Every 1.5 feet a wooden stick about 1-foot long and 1-inch in diameter is inserted through the ropes to keep the mussels from sliding off.

A 30-foot rope produces over 250 pounds of live mussels annually and a 700-rope raft produces over 90 tons of mussels in the shell, or as much as 90,000 pounds of drained meat annually. One acre of water surface can support between three and five rafts. In an intensively cultivated area, 1 acre can produce more than 250,000 pounds of pure meat per year.

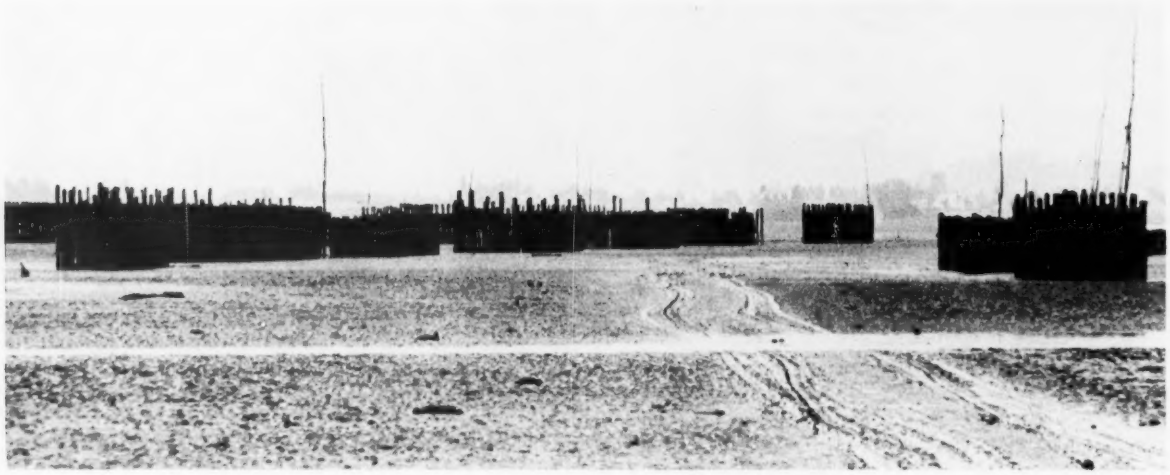
When mature, the mussel-laden ropes are hoisted aboard a workboat with a winch. A large wire-mesh basket is lowered under the rope before it is lifted. When on the workboat the rope is given a vigorous shake and the mussels fall off. Those of unmarketable size are wrapped onto new ropes for transplanting. The mussels that go to the canneries, and thus to be cooked, are transported directly to the factories. Those that will be sold fresh either in Spain or outside the country, must, by Spanish law, be depurated for 48 hours.

The depuration process is relatively simple. Seawater is pumped into large holding tanks and is measured for impurities. The proper amount of chlorine is added and allowed to evaporate, after which the water is pure. The mussels are placed on racks in tanks—usually shaded—and the purified water is slowly pumped over and through the racks for 48 hours. The mussels, now being certified clean, are placed in 15-kilogram (33-pound) mesh bags, sealed, tagged, and rinsed. After draining for 3 hours they can be shipped in unrefrigerated closed trucks for as long as 3 days.

Those mussels that go direct to the canneries are cooked in a conveyor steamer. They are shucked by hand and proceed down the production line for frying or to be covered by various sauces. The cans are sealed, cooked in a retort, labeled, and packed into shipping cases for worldwide distribution.

Spain is the world's largest producer of cultured mussels. The annual yield is in excess of 220,000 tons in the shell. Ninety-five percent of this is derived from the five Galician bays, where there are over 3,000 rafts. About 45 percent is canned, 5 percent frozen, and the remainder sold fresh. Of that sold fresh, about 25 percent is exported to France and Italy.

From two to four mussel rafts of average size can support a family well,



Mussel bouchots near Le Mont Saint-Michel, France. C. G. Hurlburt photo.

and generally this is a family enterprise, although there are some groups that own 20-30 rafts and hire employees. The water surface upon which the rafts float is leased from the government.

The depuration process is often a separate enterprise. The depurators buy the mussels from the growers and, in turn, sell them to the dealers. Sometimes the depurators purify the mussels for the growers (for a fee) who prefer to market their own. Some of the waste shells are ground and the high-calcium product is used to enrich the acid soil of farmland.

The Spanish mussel mariculture industry is innovative, uncomplicated, and profitable. It requires much hard work—and hard work is typical of fishing and fishermen worldwide.

ATLANTIC COAST OF FRANCE—POLE CULTURE

From the south Atlantic Coast of France, north through the coastal regions of Brittany and Normandy, mussel mariculture is accomplished by the pole or "bouchot" method. Here the coast is made up of long, gradually sloping beaches extending far out to sea. These beaches and the ocean floor are unprotected from the storms and other vagaries of nature. The salinity of the water varies between 29 and 34 parts per thousand depending on the season, and the water temperature fluctuates between 40° and 70°F. The tremendous tides are perhaps the most unusual feature of much of this coastline. In some northern areas there is at times a difference of about 50 feet between high and low water. This has both advantages and disadvantages for the mussel growers.

At low tide the ocean floor (beach) is bare sand or mud for many miles. In the southern regions where the tidal fluctuations are not as severe, much of the pole mariculture is conducted by boat and the bottom of the poles is seldom exposed to the air. The oak poles, about 8 inches in diameter, are driven into the ocean floor and the top 5 feet of the poles, exposed at low tide, is where the culture takes place. At low tide the fishermen tend the poles by boat. The poles are placed in long rows. They are about 3 feet apart and there is about 12 feet between the rows.

In the northern regions where the tidal differences are the greatest, the 12-foot oak poles are driven into the sand, leaving 6 or 7 feet above the sand. The bottom 1-foot of the pole is wrapped with a smooth plastic to discourage starfish, crabs, and other natural enemies. In this region at low tide the mariculture is conducted on foot. The fishermen—in tractors, on horse or ox-carts, and even on bicycles—ride out for miles to their "bouchots."

The pole method of mariculture in France was accidentally discovered in the mid-13th century. The principle involved has remained virtually unchanged since that time. An Irish sailor named Walton was shipwrecked and put ashore at Esnandes near La Rochelle in southwest France. He sank some poles into the ocean mud and stretched nets between them to catch sea birds for food. He quickly observed that mussels in great abundance grew on the poles, and thus began the "bouchot" system of mussel mariculture. In the Bay of Aiguillon where Walton came ashore there are now over 2.5 million poles—more than 50,000 rows of 50 poles each. In total, along the French coastline today there are about 700 miles of these rows of mussel poles.

Whether the poles are tended by boat as in the south, or on foot or cart as in the north, the system is very much the same with one exception: in the south where the tides are more gradual the seed is gathered naturally on ropes laid out for that purpose near areas of natural mussel beds. Within several weeks the natural seed mussels have attached themselves to the ropes and are ready for transplant to the poles. The seed ropes for the north must also come from the southern region as the great tidal velocity of the north prevents any natural local seed setting.

In both regions, however, after the seed stock is gathered on the ropes it is wrapped around the poles. The mussels grow, multiply, and rapidly fill the entire post, and soon grow several layers thick; at this time they must be thinned out by the fisherman who pulls off the outer layers and places them in long plastic net tubes (about 6 feet long, 6 inches in diameter). These flexible mesh cylinders are then wrapped around bare poles to start the process again. It takes from 12 to 18

months to have a mussel of marketable size (about 3 inches long).

After they are harvested—either by boat or on foot—the clumps are broken apart, washed, and separated for size. The marketable ones are placed in 20-kilogram (44-pound) burlap sacks —all to be sold fresh in France. There is no mandatory depuration in France, and few mussels are subjected to this process as they are grown in the clean open ocean. The mussel farming areas are constantly monitored by the French Government. If found to be polluted, they are closed until the situation corrects itself.

Those who work the "bouchots" by foot, ox cart, tractor, or little flat-bottomed mud boats called acon, miles out on the flats near Le Mont Saint-Michel, must be ever conscious to get to the mainland before the tremendous tidal bore surges toward them. As in Spain, the Government of France leases the mussel growing areas to the farmers. Most of the "bouchots" are conducted as a family enterprise with an average count of from 15,000 to 20,000 poles. A few of the largest farmers may have as many as 75,000 poles. One pole will yield about 20-25 pounds of live mussels per year, or about 10 pounds of meat. One acre will yield about 5 tons of live mussels, or over 4,000 pounds of meat annually. France produces over 50,000 tons of live mussels annually and all are sold fresh. In fact, the great demand in France for live mussels means that an amount almost equal to domestic production is imported fresh from neighboring coastal countries each year.

THE NETHERLANDS—BOTTOM CULTURE

The third and final method of mussel mariculture we will describe is bottom culture as practiced in The Netherlands. This method of farming the sea is closest to natural growth of wild mussels, but the harvesting, cleaning, and storage is and will be more highly mechanized. Mussel farming has existed for more than 300 years in The Netherlands. This mariculture is accomplished on the bottom of the shallow, partially diked, or enclosed seas. The mussel farmers here also lease their culture plots from the government.

The wild mussel seed is dredged up by boat from natural growth areas when it is from 0.33- to 0.5-inch long. It is then transplanted to the farmers' culture plots at depths of from 10 to 20 feet. These seed mussels mature to their marketable size of approximately 3 inches in about twenty months.

Most Dutch mussels are grown in the Waddenzee. This sea is on The Netherlands' northwest coast and is protected from the North Sea by encircling islands. The Waddenzee has a muddy bottom and when the mature mussels are mechanically dredged they ingest sufficient silt to make them undesirable. So they are taken down the full length of the Dutch Coast to the Rhine estuary near the Belgian border. Here they are deposited on the hard, sandy bottom of the bay where they cleanse themselves of the silt in the clean tidal water. They are stored here until they have regained their strength and/or until market conditions are favorable.

Dutch mussel growers now produce in excess of 100,000 tons of mussels annually. This, at 30 percent yield, makes over 30,000 tons of clear meat. Eighty percent of the production is sold fresh—most being exported to France and Belgium; the remaining 20 percent is processed into cans and jars for worldwide distribution. With the bottom culture method the Dutch farmers can produce approximately 25 tons of live mussels per acre annually, or about 15,000 pounds of clear meat per acre.

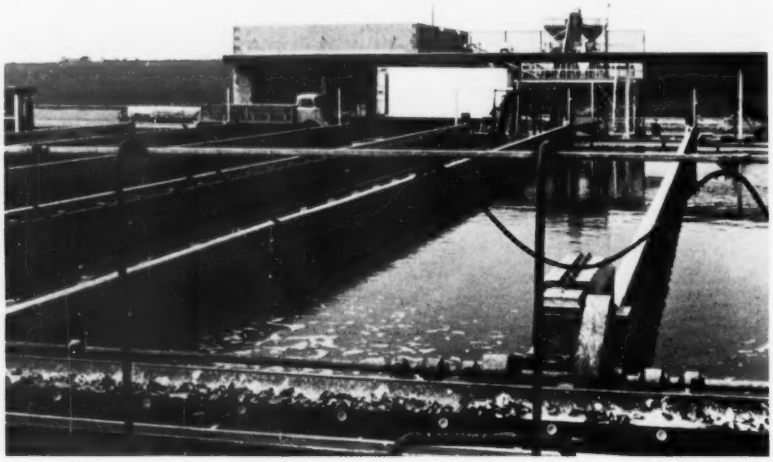
Fisherman with seed mussels ready to transplant onto bouchot, Charron, France. C. G. Hurlburt photo.

The mussel farmers of The Netherlands are now facing a serious, and peculiarly unique problem. The mussel cleansing areas in the south will be diked before 1980, thereby rendering useless the Rhine estuary as a mussel production and storage area.

To preserve this most valued industry the Dutch Government has developed a new, highly mechanized method for cleansing and storage of mussels.

Mussel fisherman thinning bouchot, Charron, France. C. G. Hurlburt photo.

Mussel fisherman going to work at low tide, Le Vivier-sur-Mer, France. C. G. Hurlburt photo.



Mussel experimental station and processing area, Isle of Texel, The Netherlands. C. G. Hurlburt photo.

Briefly, this involves bringing clean seawater into large tanks where the sediment settles out. This water is then pumped over and through the mussels stored in large concrete holding basins. This is similar to the depuration process used in Spain described above but is not necessarily for purification. The mussels are mechanically conveyed to a scrubbing machine which separates them and cleans the unwanted debris from their shells. From this point they are conveyed to a weighing and bagging area, and are ready for shipment.

The government mussel experimental processing station is located on the Isle of Texel, which separates the North Sea from the Waddenzee. It is now able to cleanse and process 5 percent of the Waddenzee production. In time it is planned that individual mussel processors will have their own storage and cleansing plants to service the mussel fishermen of the Waddenzee. This will insure a steady supply of an excellent product to the growing marketplace.

The Dutch process from seed to market is highly mechanized and for this reason their mussels are very good competitors. This high degree of mechanization however has certain drawbacks. An important one involves the amount of rough handling of the live mussel. This "shock" makes the mussel less durable, particularly pertaining to the live transport time. The mussel experiment station on the Isle of Texel is working to alleviate this condition.

We have explained briefly three methods of growing a very desirable high-protein food product. These have evolved into big and profitable industries, actually creating large quantities of meat and significant employment. It is reasonable to say that 1 acre of grazing land can produce 300 pounds of clear boneless beef meat. We can compare that to 4,000 pounds of clear mussel meat in France; 15,000 pounds in The Netherlands; up to 300,000 pounds in Spain.

What are the problems or opportunities we might encounter in trying to develop a similar industry in North America or elsewhere?

(1) A marketing problem (which we feel can be easily overcome, particularly at this time).
(2) A "real estate" problem (being able to obtain or lease saltwater rights for "farming").
(3) Perhaps government "seed money" to help initiate the industry and resultant employment.
(4) Education for the grower, the ultimate consumer, and all those in between.
(5) Development of mechanization to fit the various types of mariculture.
(6) Pursuit and completion of economic feasibility studies.

In North America, mussels (*Mytilus edulis*) grow wild in the tidal and intertidal zones from the Arctic Ocean to Cape Hatteras on the East Coast and from the Arctic Ocean to San Francisco on the West Coast. Where they grow wild in great abundance it is reasonable to assume they could also be cultivated. Where they do not grow in abundance in the wild state, experience in Europe and elsewhere would lend credence to the fact that they could be farmed successfully in many regions.

Mussels that grow completely underwater mature faster than those that are exposed twice a day to the air. This would account for the larger per-acre annual yield obtained in Holland as compared to France, even though the mussels in France (which are exposed at low tide to the air) are grown cubically, and those in Holland (with little or no exposure to the air) are grown on a plane, or flat on the seabed. This would also partially account for the tremendous yields per acre produced in Spain where the mussels are both grown cubically and are always submerged. For that reason alone it would appear wise for those contemplating mussel culture in the United States, Canada,

or elsewhere to strongly consider cubic and totally submerged farming, whether it is by the raft-hanging rope method or otherwise. Like other forms of farming it is obvious that the larger the scale of operation, the more economical it is.

The mussel as a human food is certainly one of the most efficient producers of edible flesh. It has been estimated that there is a 90 percent energy loss in the conversion of food into meat. Mussels are very close to the beginning of the food chain, and therefore there is actually little waste as compared to finfish, beef, and other flesh foods. Big fish have eaten little fish, who have eaten smaller fish, etc.—each time a 90 percent loss of energy. It takes about 8 pounds of feed to produce 1 pound of edible beef. A steer consumes 21 pounds of protein in order to produce 1 pound of protein.

Imagine—43 billion pounds of flesh meat per year from an area of water the size of Cape Cod Bay, which is approximately 18 miles by 15 miles. At the annual mussel production rates now being achieved in northwest Spain this is theoretically possible. This much high-protein meat would provide every living person in the United States with 1 ton of meat per year (average 1972 beef consumption was 116 pounds per person), or every man, woman, and child on earth with 10 pounds of nutritious meat per year! In less than 300 square miles! It is technically feasible now.

The meat of the mussel is extremely nutritious. Studies reveal that the edible blue mussel not only has the same kind of nutrients as other shellfish, but has them in greater quantity and quality. Of the five species of common shellfish listed below, the mussel ranks first, second, and third respectively in the yield of carbohydrate, fat, and protein. It is undisputedly superior in the total production of nutrients and food fuel value.

Comparative composition and fuel value of certain shellfish in percent[1].

	Sea mussel	Lobster	Long clam	Round clam	Oyster
Refuse	46.7	61.7	41.9	67.5	81.4
Water	44.9	30.7	49.9	28.0	16.1
Protein NX6.25	4.6	5.9	5.0	2.1	1.2
Fat	0.6	0.7	0.6	0.1	0.2
Carbohydrate	2.2	0.2	1.1	1.4	0.7
Ash	1.0	0.8	1.5	0.9	0.4
Total nutrients	8.4	7.6	8.2	4.5	2.5
Calories of fuel value/lb	150	141	136	68	41

[1]Data from Langworthy, C. F. 1905. Fish as Food.

Compared with beef (T-bone steak, choice), mussel meat is most attractive. This is well illustrated by the following nutritional audit taken from U.S. Department of Agriculture Handbook No. 8, *Composition of Foods* (December 1963).

3½ oz raw meat	Common blue mussel	T-bone steak (choice)
Calories	95	395
Protein	14.4 g	14.7 g
Fat	2.2 "	37.1 "
Carbohydrates	3.3 "	0 "
Calcium	88 mg	8 "
Phosphorus	236 "	135 "
Iron	3.4 "	2.2 "
Thiamin	0.16 "	0.06 "
Riboflavin	0.21 "	0.13 "

Mussels can be prepared from the fresh stage in countless different and attractive ways. They can be preserved by canning, freezing, drying, smoking, and pickling; all delicious! They can be readily processed into high-quality, nutritious protein concentrate, odorless and tasteless, which could be incorporated into new or familiar foods for protein starved, underdeveloped areas of the world.

Authors with mussel culture ropes, Duxbury, Mass. Leeds Hurlburt photo.

Regarding the palatability of mussel meat, it is tender, of high quality and—as attested to by hundreds—its flavor is superior to clams, equaling that of oysters. It is readily digestible and the proportion of nutrients supplied to the body is almost identical to those supplied by steamed beef which is considered to be highly digestible.

Therefore, one could draw the conclusion that mussel meat is highly desirable—it is most palatable, and could be now and in the future the cheapest, most nutritious, and most abundant of not only shellfish, but of any meat on the world market.

We believe the edible blue mussel can materially aid in solving the rapidly inflating world food crisis. This global protein deficiency is brought into focus when we realize that the world population growth has now reached a rate where population will double every 37 years.

As the late President John F. Kennedy said before the Food and Agriculture Organization of the United Nations in 1961:

> "A first responsibility of the human race is to see that its members have enough to eat. . .Nutritional problems are not peculiar to countries where food is scarce. Protein malnutrition is, in fact, a serious disease affecting nearly two-thirds of the world's population. There is, therefore, an urgent need for the exploitation of what is probably the major untapped source of food: products from seas and inland waters. . . Your part in the task that lies ahead, like that of other dedicated people in commerce, in laboratories, in factories, farms and fishing boats, is to recreate the miracle of the loaves and fishes. . .a miracle no less spiritual for being scientific."

We might add, it can be done and it will be done, practically and profitably. With one known exception the authors now have the first mussel culture ropes in place in North America. The early results appear encouraging.

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MFR PAPER 1163

Housing Development Canals in the Coastal Zone of the Gulf of Mexico: Ecological Consequences, Regulations, and Recommendations

WILLIAM N. LINDALL, JR. and LEE TRENT

ABSTRACT—Three types of housing development canals (bayfill, inland, and intertidal) are described, and their effects on estuarine flora, water and sediment quality, and species composition and abundance of fauna are discussed. Varying only in degree, all three types of canal development are similar in adversely affecting the integrity of the estuarine ecosystem.

Existing legislation, designed to minimize adverse alteration in the estuarine zone, is discussed. Presently, full jurisdiction is not exercised over inland canal development. Recent court decisions, however, indicate that jurisdiction will be fully exercised in the near future. To insure continued propagation of estuarine-dependent fish and wildlife resources, guidelines for the location and design of inland canal development are presented.

INTRODUCTION

Population growth in the coastal zone of the United States has intensified the demand for multiple utilization of estuaries, including such activities as petroleum production, shipping, outdoor recreation, commercial and recreational fishing, waste disposal, and the ever-increasing development of residential waterfront real estate. Each user has a legitimate interest in the estuary and the significance of the estuary to each use is well recognized (Sweet, 1971). However, many of the uses are incompatible and inevitable conflicts have evolved among the various interests. Increased environmental awareness in recent years has focused much attention on these conflicts.

William N. Lindall is with the Environmental Assessment Division, Southeast Regional Office, National Marine Fisheries Service, NOAA, 9450 Gandy Boulevard, St. Petersburg, FL 33702. Lee Trent is with the Panama City Laboratory, Gulf Coastal Fisheries Center, National Marine Fisheries Service, NOAA, Panama City, FL 32401.

One of the prominent conflicts is between fishing interests and the developers of waterfront property for residential use. Fishing interests, both commercial and recreational, wish to maintain the estuarine zone in its natural state (except for alterations, such as ports, marinas, and fish processing plants, necessary to pursue their interests) to assure continued propagation of fish and wildlife resources. Conversely, developers are prompted by premium prices home buyers are willing to pay for waterfront housing and are converting prime estuarine habitat to waterfront real estate.

The reason for the conflict is readily apparent. Estuaries provide food and sanctuary for all or part of the life history stages of the majority of commercial and recreational fishes. Of the 26.6 million acres of estuarine area in the United States, only about 29 percent (7.9 million acres) are considered prime habitat for the propagation of fish and wildlife resources (U.S. House of Representatives, 1967). Much of the prime habitat is along the peripheries of estuaries and is easily and relatively inexpensively converted to waterfront residential real estate. Captivated by the prospects of waterfront living, homebuyers are attracted to such communities. Unregulated development, however, can result in deterioration of communities as well as aquatic resources (Barada and Partington, 1972; Marshall, 1974).

The objectives of this report are to: 1) briefly review the effects of housing development canals on the estuarine environment; 2) discuss some of the regulatory legislation enacted to prevent destructive alterations in the estuarine zone; and 3) present recommendations for minimizing damage to coastal resources that is often caused by unregulated development of waterfront property.

TYPES OF DEVELOPMENT

Waterfront housing developments created by excavating canals in the estuarine zone can be categorized as *bayfill*, *inland*, and *intertidal*, depending on their location with respect to tide levels. *Bayfill* developments are those constructed below mean low tide by dredging and filling shallow bay bottoms (Fig. 1). Typically, hydraulic dredges are used to create finger-like projections of land stabilized by vertical bulkheads. About 3 acres of submerged bottom are required to create one acre of fill (Odum, 1970) unless fill material is imported to the area. *Inland* developments are those constructed by excavating areas above mean high tide and connecting the resulting canals to natural channels or to the open bay (Fig. 2). Inland canals are usually excavated by draglines (bucket dredges), but hydraulic dredges may be used where feasible. Typically, an earthen dam (a small unexcavated segment of the canal system) is left in place at the mean high tide line until the interior canal system is completed; the excavated material is exported from the area or used as fill to obtain the required elevations for housing construction on the adjacent lots; and the banks are stabilized by vertical bulkheads. Bayward of the earthen dam, one or more access canals are excavated to provide boat passage to deeper water. The earthen dam is then removed, thereby connecting the canal system to natural channels, man-made channels, or open bay waters. *Intertidal*

Figure 1.—Example of bayfill development. (Photo courtesy of Dillon Aerial Photography, Inc.)

developments, as the name suggests, are those constructed in the area of the shoreline between mean-low and mean-high tides (Fig. 3). In coastal areas where the intertidal area is extensively broad, the entire development may be located in the intertidal zone. In most cases, however, this type of development will include areas below and above the intertidal zone.

EFFECTS ON THE ESTUARINE ENVIRONMENT

Regardless of their location with respect to tidal level, all three categories of canals may seriously degrade coastal resources. Environmental damage is caused mainly by poor excavation practices and inadequate provisions for good water circulation. As a result, canal construction often causes destruction of wetland vegetation, undesirable changes in water quality and sediment type, and qualitative and quantitative faunal changes. These three major effects are discussed below.

Destruction of Wetland Vegetation

Bayfill and intertidal development often cause alteration and eradication of large areas of shallow bay bottom, submerged vegetation, and emergent vegetation in the intertidal zone—usually the most productive part of the estuarine ecosystem. The area covered by the fill is permanently removed from production, and the canals are usually excavated to depths below the limits of sunlight penetration (below the euphotic zone) which precludes the reestablishment of rooted vegetation. Inland developments alter only relatively small areas of intertidal and subtidal vegetation (as a result of access canals), but often alter large areas of marshland above mean high tide. Marsh vegetation plays an important role in filtering run-off from uplands and providing detrital material, a basic energy source, to the estuarine system. The inland canals and associated fill permanently destroy marsh vegetation, and the fill serves as a barrier to marsh drainage and flushing.

Changes in Water Quality and Sediment Type

Water and sediment quality are usually lowered in the canals, because the canal system is typically labyrinthine, contains dead ends, and is excessively deep. This degradation stems primarily from a lack of adequate water exchange with the parent body (natural stream, bayou, or bay) of water. For example, along the U.S. Gulf coast, where most studies of canal systems have been conducted, the canals are usually excavated to depths of 2-3 m (some as much as 6 m) in areas of the estuary where natural depths are 1 m or less. Average tidal range is less than 1 m in most areas of the Gulf of Mexico. If a uniform 3-m deep canal system (mean high tide) were dug in an estuarine area where the natural depth was 1 m and the average tidal range was

Figure 2.—Example of inland canal development. (Photo courtesy of Dillon Aerial Photography, Inc.)

0.5 m, the theoretical amount of water mass exchanged with each tidal cycle would be 50 percent in the natural area, but only about 17 percent in the canals. Water currents, especially near the bottom, would be much slower in the deep canals than in the shallow, subtidal areas. Owing to low current speeds, the canal bottoms serve as settling basins that readily accumulate large quantities of fine silts and biogenic materials, the results of which are discussed below in the section on faunal changes.

Increased water depth and the resulting low water exchange rates in the area following alteration affect water quality, particularly oxygen concentration. Usually, increased water depth creates a water mass with lower inorganic turbidities and a greater capacity for producing phytoplankton (deeper zone for sunlight penetration) than in the area prior to alteration (Taylor and Saloman, 1968; Corliss and Trent, 1971). The zone below sunlight penetration, however, becomes an oxygen-demanding rather than an oxygen-producing zone, and this demand is increased in relation to the amount of biogenic material on the bottom. The canals not only have a great potential for phytoplankton production but for overproduction as well. Overproduction results in a water mass deficient in dissolved oxygen. Although the increased concentration of phytoplankton produces large amounts of oxygen (part of which is retained in the water) during the day through photosynthesis, most or all of this oxygen is removed at night as a result of respiration by phytoplankton and other organisms. Also, the phytoplankters die because of low oxygen, settle below the euphotic zone, and create even heavier demands on dissolved oxygen as they decompose. Such oxygen deficiency is more likely to occur and slower to correct itself in a canal than in a shallow, more open area, because of the canal's slower rates of water exchange. This situation has been documented by the above authors and several others (Reish, 1961; Trent, Pullen, and Moore 1972; Lindall, Hall, and Saloman, 1973).

Other factors that cause reductions in oxygen concentrations in canals of completed developments include reduced aeration of the water (caused by narrowness of the canals and the houses blocking and diverting prevailing winds) and increased concentrations

Figure 3.—Example of intertidal canal development.

of organic material caused by increases in nutrients and biogenic materials from storm runoff (Moor and Trent, 1971).

Qualitative and Quantitative Faunal Changes

Published biological studies of housing development canals in the estuarine zone indicate, with the possible exception of phytoplankton, that species composition, abundance, growth, or reproduction of organisms can be expected to be detrimentally affected by reduced water and sediment quality that usually occurs in the canals.

As a direct or indirect result of low dissolved oxygen, which occurs principally in the summer months, researchers working in canals in the estuaries of the Gulf of Mexico have documented that: 1) abundance and species composition of benthic organisms were reduced in Texas (Gilmore and Trent, 1974) and Florida (Hall and Lindall, 1974); 2) oysters reproduced less, and suffered higher mortalities in Texas (Moore and Trent, 1971); and 3) the abundance of fishes and crustaceans was reduced in Texas (Trent, et al., 1972) and in Florida (Lindall, Fable, and Collins, 1975). Low dissolved oxygen also was suspected of causing a reduction in the abundance and species composition of benthic organisms in boat-basin canals in California (Reish, 1961).

Comparisons of the relative abundance of benthic organisms in dredged canals and undredged areas in Boca Ciega Bay, Fla., indicate the adverse effects of large-scale accumulation of fine sediments in the canals. Taylor and Saloman (1968) found that sediments in the dredged canals averaged 92 percent silt and clay, whereas those in undredged areas averaged 94 percent sand and shell. Although they had been in existence for 10 years, the deeply dredged canals contained less than 1 percent of the number of benthic organisms recorded from both areas. A detailed examination of mollusks from these same canals was made by Sykes and Hall (1970) who showed that samples from undredged areas contained an average of 60.5 individuals and 3.8 species, whereas those from the dredged canals contained an average of 1.1 individuals and 0.6 species.

REGULATORY MECHANISMS IN MANAGEMENT

Historically, the controversy between fishing interests and real estate interests focused primarily on bayfill developments in Florida (Sykes, 1967). Because of their damaging effects on the estuarine environment, Federal legislation was enacted which established the means for abolishing indiscriminate dredging and filling below the level of mean high water (McNulty, Lindall, and Sykes, 1972). The Fish and Wildlife Coordination Act of 1958 (P.L. 85-624) requires that living aquatic resources be equally considered with other project features in the issuance of Federal permits for construction in navigable waters, and the National Environmental Policy Act of 1969 (P.L. 91-190) requires that Federal agencies consider environmental matters in the administration of public laws.

The former legislative act was applied by the U.S. Army Corps of Engineers in its unprecedented denial of a dredge-fill permit in Boca Ciega Bay, Fla., on the grounds that the work was not in the general public interest because of damages to fish and wildlife resources. The constitutionality of this denial was confirmed in the *Zabel* v. *Tabb* decision by the U.S. Court of Appeals in July 1970 (U.S. House of Representatives, 1974). Since then, most bayfill proposals have been largely curtailed or modified to insure protection of estuarine resources.

In response to statutory restraints on bayfill development, waterfront real estate developers have turned to canal excavation in areas above mean high tide, and the conflict now centers around these inland canals. Because inland canal development takes place above mean high water, the development is usually unregulated by Federal authority except for the requirement of a permit to construct one or more access canals from the development to navigable waters and to remove the earthen dam. Ironically, Federal legislation exists that provides the potential for regulating dredging and filling inland areas, but the design and construction of inland housing developments in estuarine areas are essentially uncontrolled at the present time. The explanation for this incongruity is discussed in a recent report by the Committee on Government Operations (U.S. House of Representatives, 1974). the Corps Section 404 of the Federal Water Pollution Control Act (FWPCA) Amendments of 1972 authorizes the Corps of Engineers to issue permits for the discharge of dredge or fill material into "navigable waters" at specified sites. The Environmental Protection Agency (EPA), which is primarily responsible for administering the FWPCA amendments, interprets the phrase "navigable waters" to include wetlands above the line of mean high water. However, the Corps' interpretation of the Act is that its jurisdiction is limited to all lands and waters below the ordinary high water mark. These interpretations were tested in the 1974 case of *United States* v. *Holland* held in the U.S. District Court for the Middle District of Florida. The Court agreed with EPA's interpretation and concluded that under the FWPCA Amendments of 1972 the Corps has authority to regulate and protect against deposits of dredge or fill material in wetlands above the mean high water line.

According to the Committee on Government Operations (U.S. House of Representatives, 1974), the Corps declined to acquiesce in the Holland decision and refused to exercise its jurisdiction over inland canals, except to require a permit to connect them with navigable waters. Thus, wetlands above mean high tide, although vital to the total function of the estuarine ecosystem, are essentially unprotected from indiscriminate dredging and filling. By the time permit application is made to connect the canal system with open water, the wetlands above mean high water usually have suffered irrevocable damage by the development. In most cases, relevant fish and wildlife agencies, whose statutory responsibility is to assess these permit applications, have no recourse but to recommend denial, because the traditional design and location of the development would be a liability to water quality and estuarine-dependent resources. Not only does the present process allow the extensive alteration of wetlands, it precludes fish and wildlife agencies from accomplishing their mandate and is confusing to the developer and the public.

A more recent court decision, however, is encouraging. On 27 March 1975, the U.S. District Court in Washington, D.C. ordered the Corps of Engineers to promulgate new regulations expanding their definition of "navigable waters" to include areas above the line of mean high water. The ruling came in a suit brought by the Natural Resources Defense Council and the National Wildlife Federation and should expand the Corps' jurisdiction to include inland canal development.

CONCLUSIONS AND RECOMMENDATIONS

State and Federal jurisdiction is being exercised to control development in estuarine areas below mean high tide. However, with respect to maintaining productive estuarine areas, mean high tide is an arbitrary demarcation point. To insure continued propagation of estuarine-dependent fish and wildlife resources, development of wetland areas above mean high tide must also be regulated, especially those that will contain "navigable waters" after canals are constructed.

Based on recent court decisions, the Corps of Engineers apparently will begin exercising full jurisdiction over inland housing development canals in the near future. Therefore, real estate developers contemplating inland canal development should request a Corps' permit prior to beginning excavation. Meanwhile, guidelines for the location and design of inland canals must be developed that are compatible with continued high production of fish and wildlife resources. As an initial effort toward achieving this, we recommend the following:

I. Avoid disruption of wetland and subtidal habitats to the greatest extent possible.
   1. Restrict residential lots and their adjacent canals to non-wetland areas, i.e., on high and dry land.
   2. Route access canals from the housing development to the parent body of water by the shortest and least environmentally damaging route possible, i.e., avoid intertidal marsh, submerged grass beds, and oyster reefs. Alignment should take advantage of existing natural or manmade channels.
   3. Control turbidity and sediment dispersion as much as possible.
      a. Complete all construction of housing development canals before connecting them with the access canals.
      b. Excavate access canals using the best dredging techniques available, i.e., use turbidity control screens and dispose the excess spoil in diked non-wetland areas.
      c. Reserve adequate spoil disposal sites and easements in non-wetland areas for future maintenance dredging.

II. Design the canal system so that State and Federal water quality standards, especially for dissolved oxygen, will be maintained at all times. This can be accomplished if the entire canal complex is designed as a flow-through system that provides adequate water exchange with the parent body of

water, and if nutrient input is maintained at low levels. Water exchange rates should be determined for each area considered for development, and for each plan of canal layout, by an environmental engineer who has expertise in hydraulics and coastal circulation. In addition to the design criteria in I above, the engineer should consider the following:

1. Dead-end canals should not be permitted. Culverts and bridges should be used as methods of alleviating the need for dead-end canals.
2. Pumps should be used to increase circulation, and reaeration techniques should be used to increase dissolved oxygen.
3. Canal (interior and access) depths should not exceed that of the euphotic zone. In most areas of the Gulf of Mexico this would be 1.8-2.0 m at mean low water and is ample for navigation of small pleasure craft. Exceptions may be acceptable in areas where ambient turbidity normally results in an extremely shallow euphotic zone. However, canal depths should never exceed those of the parent body of water where the access canal terminates.
4. The entire canal system, including access canals, should be of uniform depth, or become gradually shallower, proceeding from the parent body of water to the inlandmost portion of the development. This would prevent the formation of "pockets" of stagnant water.
5. Interior canals should be as wide as possible and, where feasible, aligned with prevailing summer winds to increase aeration.
6. Canals should not be cut into an aquifer.
7. Septic tanks or effluent discharge from sewage treatment plants should not be allowed within the development.
8. Storm-water runoff into the canals should be minimized and controlled as much as possible. Adequate storm drains should be installed throughout the development and designed to direct runoff from streets and lawns away from the canals.

These guidelines are not intended to be all-encompassing, nor is strict adherence to them expected. Rather, they should be considered on the merits of each proposed project in its own particular ecological setting.

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MFR PAPER 1164

High School Students' Perceptions of Fish as a Menu Item

CHARLES W. LAMB, JR.

INTRODUCTION

This article presents the findings of a survey of high school home economics students concerning their attitudes toward, and beliefs about, fish as a menu item. The data for the study were obtained from questionnaires administered to 66 home economics students in an Austin, Tex. high school.

The respondents were told that they had been selected to participate in a study which was being conducted by researchers at Texas A&M University to determine high school students' feelings about certain food items. They were informed that there were no right or wrong answers to any of the questions.

The students were first asked to indicate how often they eat pork, fish, and beef in their homes. Next they were asked to indicate their attitudes and beliefs about pork, fish, and beef with respect to 11 product attributes. These product attributes are listed in Table 1.

These 11 product attributes were selected from a list of 24 attitudinal variables used by Sanchez and Konopa (1974) in a previous study. Respondents were asked to indicate their feelings about each product category (pork, beef, and fish) along a seven-point scale ranging from extremely favorable to extremely unfavorable. An example of the questionnaire design is shown in Figure 1.

Table 1.—Product attributes investigated in the study.

1. Taste
2. Nutrition (healthfulness)
3. Cost/price
4. Aroma (odor, smell)
5. Perishability
6. Difficulty of preparation before cooking
7. Cooking difficulty
8. Appearance (color, eye appeal)
9. Quality (freshness)
10. Wholesomeness (safe to eat)
11. Image as a menu item (special treat for dinner)

Finally, respondents were asked to indicate how important they considered each of the 11 product attributes in preparing the main dish for the average evening meal in their home. A seven-point scale ranging from unimportant to important was provided for their evaluations.

Some of the important findings of the study are discussed below. The paper is divided into three major sections. The first section discusses how respondents perceive fish compared to beef and pork with respect to the 11 product attributes listed in Table 1. A comparison of how often respondents eat beef, fish, and pork in their homes is also included. The second section presents respondents' evaluations of the importance of the product attributes listed in Table 1 in preparing the average evening meal. The third major section summarizes the findings of the survey and suggests implications for marketing strategy.

	EXTREMELY	QUITE	SLIGHTLY	NEITHER ONE	SLIGHTLY	QUITE	EXTREMELY
		←GOOD		TASTE		BAD→	
PORK							
BEEF							
FISH							

Figure 1.—Sample questionnaire design used to obtain respondents' feelings about each product category (pork, beef, and fish) on a seven-point scale.

RESPONDENTS' PERCEPTIONS OF FISH COMPARED TO BEEF AND PORK

Gillespie and Houston (1974) have noted that the status of fish as a menu item is considerably less than that of either beef or pork. They cite as evidence that in 1972 average consumption of red meat was 189 pounds per person while per capita consumption of fish was only 12 pounds. Table 2 summarizes the responses to the question, "How often do you eat each of the following food items in your home?"

The data indicate a considerable difference in the frequency of usage among the three product categories. In order to help understand why fish is served less often in the home than either beef or pork, respondents were asked to evaluate the three product categories in terms of the 11 product attributes listed in Table 1. Figure 2 shows the mean values of the respondents' perceptions of the three product categories. The figure indicates that respondents perceive all three product categories favorably on all dimensions utilized in the study. However, fish as a menu item was evaluated less favorably than either beef or pork in terms of taste, aroma, preparation before cooking, appearance, and wholesomeness. It was evaluated less favorably

Table 2.—Frequency of product usage.[1]

Frequency	Beef	Pork	Fish
		Percent	
Three or more times per week	78	34	8
Two or three times per month	16	36	37
About once per month	3	23	28
Seldom or never	3	6	27

[1] $n = 64$

Charles W. Lamb, Jr., is with the Department of Marketing, College of Business Administration Texas A&M University, College Station, TX 77843.

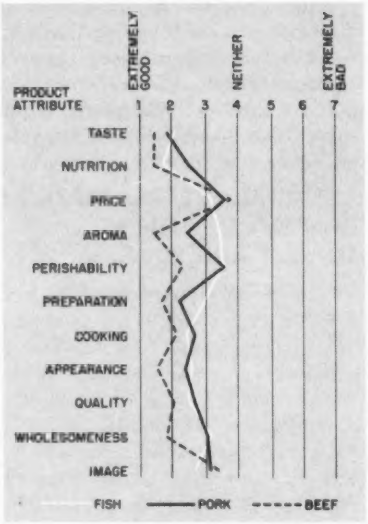

Figure 2.—Respondent beliefs about beef, pork, and fish (mean values).

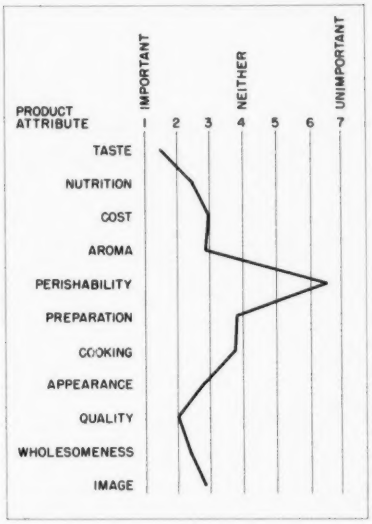

Figure 3.—Respondent beliefs concerning the importance of product attributes in preparing the average evening meal (mean values).

than beef yet more favorably than pork in terms of nutrition, perishability, cooking, and quality. Fish was evaluated more favorably than either beef or pork in terms of price and image as a menu item.

In terms of the intensity of favorability of fish on the 11 dimensions, Figure 2 indicates that fish was rated very favorable (1-2) in terms of nutrition, favorable (2-3) in terms of taste, preparation, cooking, appearance, quality, wholesomeness, and image as a menu item, and slightly favorable (3-4) in terms of price, aroma, and perishability.

Several observations are apparent from these findings. As noted previously, the mean responses indicate that all three product categories are perceived favorably on all dimensions used in the study. If price and image as a menu item were the only criteria used in selecting the main dish for evening meals, we could expect fish usage to be much higher. It is interesting to note that respondents perceive fish as only slightly favorable in terms of price, yet it is perceived more favorably than either beef or pork.

Based on the usage data presented in Table 2 it is apparent that other product characteristics are important in the overall decision-making process. The relative importance of the 11 product attributes is discussed in the following section.

IMPORTANCE OF PRODUCT ATTRIBUTES

Figure 3 summarizes the mean responses to the question, "How important do you consider the following characteristics in preparing the average evening meal?" The data indicate that respondents perceive taste and quality to be very important (1-2) in the selection of an item for the main dish at the evening meal. Nutrition, cost, aroma, appearance, wholesomeness, and image as a menu item are all considered important (2-3) in the selection of an item for the evening meal. Preparation before cooking and cooking are perceived as somewhat important (3-4). The perishability of the product is considered very unimportant (6-7).

Table 3 summarizes the information provided in Figures 2 and 3. The product attributes are ranked in order of their rated importance in the first column. Column two indicates how respondents evaluate fish in terms of the 11 product attributes. The third column lists respondents' ranking of fish compared to beef and pork on the 11 product attributes.

Looking first at the product attributes which were rated as very important, respondents rated the taste and quality of fish favorably, yet not as favorably as beef. Fish was ranked less favorably than either beef or pork in terms of taste, the most important product attribute.

Nutrition, the only product attribute on which fish was rated very good, was found to be the fourth most important product attribute considered in selecting the main dish for the average evening meal in the home. It is also noteworthy that beef was rated more nutritional than fish, although both were rated very favorably on this dimension.

The product attributes on which fish was evaluated better than either beef or pork are image as a menu item and price. In terms of the importance of these product attributes, respondents ranked them sixth and eighth, respectively. In other words, although fish is considered more favorably than either

Table 3.—Summary of respondent beliefs

Importance of product attributes	Perception of fish on product attributes	Ranking of fish compared to beef and pork on product attribute
Very important		
taste	favorable	3
quality	favorable	2
Important		
wholesomeness	favorable	3
nutrition	very favorable	2
appearance	favorable	3
image	favorable	1
aroma	slightly favorable	3
price	slightly favorable	1
Somewhat important		
cooking difficulty	favorable	2
preparation before cooking	favorable	3
Very unimportant		
perishability	slightly favorable	2

Source: Figures 1 and 2.

beef or pork in terms of its image as a menu item and price, it is not considered extremely good on either dimension, and neither factor is highly important in selecting the main dish for an average evening meal.

SUMMARY AND IMPLICATIONS

The results of the survey indicate that fish as a menu item is perceived favorably on all dimensions utilized in the study. This finding is consistent with results reported by previous researchers (Gillespie and Houston, 1974; Sanchez and Konopa, 1974).

Respondents rated fish more favorably than either beef or pork in terms of its price and image as a menu item. Additionally, fish was rated very favorably in terms of its nutritional value. These findings suggest that seafood marketers and the seafood industry might find it useful to develop promotional campaigns emphasizing the three product attributes on which fish performs quite well. Gillespie and Houston (1974) also considered this possibility but rejected it because their data indicated that fish was not perceived as being significantly superior to substitute products on these dimensions.

Another approach to enhance the image and consumption of fish is to improve consumer perceptions along those dimensions which fish does not perform well. For example, fish was rated much less favorably than beef in terms of its aroma, perishability, preparation ease, appearance, and wholesomeness. This study has found that two of these dimensions, preparation ease and perishability, are considered to be the least important product attributes in family meal planning. These findings notwithstanding, Gillespie and Houston (1974) have suggested home economist food demonstrations and in-store sampling as strategies for improving ease of preparation beliefs. Sanchez and Konopa (1974) suggest that improved packaging and improved merchandise displays could enhance consumer perceptions of the aroma and appearance of fish.

The other two product attribute dimensions on which fish is perceived less favorably than either beef or pork are taste and wholesomeness. It is important to note that the findings of this study indicate that these product attributes are two of the most important factors considered in planning the evening meal. In order to significantly affect consumer beliefs about fish with respect to taste and wholesomeness, industry-wide effort must be undertaken. Federal and/or State support will also have to be provided to mount an effective, coordinated program to convince consumers that fish is safe to eat and can be prepared to suit a wide range of tastes. Specific techniques which might be utilized to affect consumer beliefs have been discussed elsewhere and are beyond the scope of the paper.

Finally, it should be noted that the findings reported here resulted from a small survey of high school students in one geographic location. Therefore, the findings of this study cannot necessarily be generalized to other segments of the population or other geographic areas. However, since many of the findings of this study are consistent with those reported by previous researchers, it is hoped that this project will provide information which may be useful to parties concerned with the overall market for fish, and serve as a basis for further study on a national basis.

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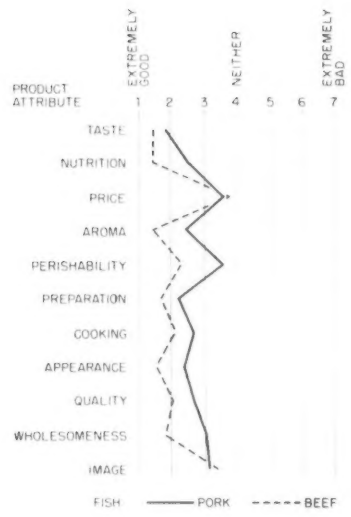

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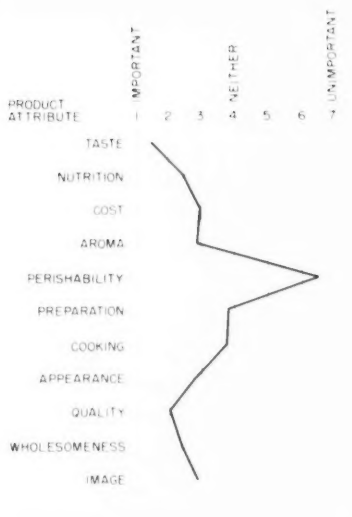

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U.S. Commercial Fishing Industry Worth $6.7 Billion to National Economy in 1973

The U.S. commercial fishing industry, with a fish catch valued at about $907 million at dockside in 1973, may have had a cumulative impact on the U.S. economy of as much as $6.7 billion, according to a study prepared for the National Marine Fisheries Service of the Department of Commerce. The study of the economic contribution of the industry, conducted under contract by a private consulting firm, Centaur Management Consultants, Inc., of Washington, D.C., was the first of its kind. It was commissioned by the Commerce Department's National Oceanic and Atmospheric Administration.

The cumulative economic impact on the economy, NMFS spokesmen said, comes from the total of wages, earnings, and employment generated by commercial fish catching, processing, wholesale and retail trade, transportation, and related industries. Thus, the $907 million catch of 1973 was the base for the estimated $6.7 billion in associated commercial activity involving, as the study showed, almost 500,000 man-years of employment.

The study also examined the position of the U.S. fishery in relation to imports of foreign fisheries products, which have been steadily increasing in recent years. It was estimated that if imports from foreign nations were replaced by domestic production, the additional economic impact might approach $3 billion, with an increase of 200,000 man-years in employment.

NOAA Marine Safety Promotion Plans Told

The National Oceanic and Atmospheric Administration has announced that an improved electronic navigation system, Loran-C, is being added to 100 nautical charts this year. The move, long awaited by commercial shipping and recreational boaters, is a major step in safety at sea.

Loran—for long range navigation—is used by ships to plot their position. Loran-C is an improved version of Loran-A, which was developed during World War II, and is now widely used by commercial fishermen, shipping, and pleasure boaters. The Loran-C chart program is one of a number of steps taken to promote boating safety and assist recreational boaters, fishermen, and commercial shipping by NOAA's National Ocean Survey, National Weather Service, and National Marine Fisheries Service.

Loran-C can operate under all weather conditions, whereas Loran-A signals are often disrupted by atmospheric disturbances. Its addition to nautical charts results from the establishment of coastal loran stations that enable the program to function. With the construction of these stations along the coast, the program to add Loran-C to nautical charts will now go into full swing. Loran-C will be printed on one side of the chart and, where appropriate, Loran-A, the older electronic navigation system, will be printed on the reverse side. The Loran-A system will continue to be used until the Loran-C program is fully in effect, probably in five years. NOAA issues 960 separate nautical charts.

The Loran-C chart program is being carried out by NOAA's National Ocean Survey, which produces and publishes most of the nation's nautical charts. Loran-C charts may be purchased for $3.25. Information regarding the charts and their purchase may be obtained from the National Ocean Survey, Distribution Division (C44), Riverdale, MD 20840. The charts may also be purchased from National Ocean Survey authorized sales agents throughout the nation.

NOAA has also announced publication of the 44-page paper-bound booklet, "So You Bought a Boat," by Robert E. Williams, a NOAA commissioned officer. A limited edition was published last year under the University of Washington Sea Grant Program. As a regular NOAA publication, the booklet will receive much wider distribution and provide boaters with numerous safety tips and hints on cruising not normally found in more conventional books on boating.

The publication contains useful information on how to avoid trouble in a boat and, in some cases, how to get out of trouble. It has chapters on the nautical chart, use of fishing instruments for navigation, the radio, weather, compass, piloting, rules of the road, boat lights, the anchor and charting products. Copies will be available from the National Ocean Survey, Distribution Division (C44), Riverdale, MD 20840. Cost is $1 per copy.

The National Ocean Survey is also updating approximately 550 of its charts in the next year to help promote the safety of the nation's 50 million boaters. New information for this purpose is being constantly gathered by NOAA's hydrographic survey vessels and through the cooperative efforts of members of the U.S. Power Squadrons and the U.S. Coast Guard Auxiliary and from other government and private sources. Eight completely revised charts will also be issued during the year.

In a further effort to promote boating safety, NOAA's marine centers in Norfolk, Va., and Seattle, Wash., are sponsoring Cooperative Charting and Chart Updating Seminars for leaders of the U.S. Power Squadrons and U.S. Coast Guard Auxiliary to equip them better for volunteer investigations in support of the nationwide chart correction programs. A new training course on Cooperative Charting has been prepared by the U.S. Power Squadrons with technical advice from the National Ocean Survey.

In the Great Lakes area, the National Ocean Survey's Lake Survey Center is furnishing boaters with vital information on lake water levels, which can vary from those published on nautical charts by as much as 4 feet or more during fluctuating high waters. The difference between actual and charted depths can be obtained from the Lake Survey Center, Federal Bldg., Detroit, MI 48226, from the agency's free Monthly Bulletin of Lake Levels.

A key role in NOAA's program to enhance boating safety is carried out by the National Weather Service. This NOAA agency prepares forecasts for shore areas of the U.S. every 6 hours, more often when conditions change

rapidly. Forecasts cover specific coastal areas, such as Block Island, R.I., to Manasquan, N.J. When strong winds or hazardous seas are anticipated, these forecasts include statements of the degree of hazard and the areas where warning signals will be displayed. Similar forecasts and warnings are issued for the Great Lakes and many inland lakes, reservoirs, and waterways.

Boaters also receive pertinent weather information over commercial radio and TV. Most stations in coastal regions make a special effort to answer the needs of boaters and shipping in their weather forecasts.

In a growing number of shore areas, weather information can now be received through VHF-FM radio stations operated by the National Weather Service. The 77 stations in operation are on the air continuously, repeating taped weather messages every 4-6 minutes. Tapes are updated periodically, usually every 2-3 hours, and revised also to meet fast-changing weather. Special receivers or tuners are required since the weather forecasts are made on 162.55 or 162.40 MHz, considerably above commercial FM frequencies. Such receivers now cost from $15 to $200.

The National Weather Service has also established a more widespread distribution of its "Marine Weather Services Charts," which list for various coastal areas and the Great Lakes information on how to obtain up-to-date weather information. These charts are now available from the National Ocean Survey's 1,087 nautical chart sales agents.

The National Marine Fisheries Service will make available again to commercial fishing vessels safety placards on how to deal with emergency problems at sea. The placards will be suitable for posting aboard vessels.

Skywave Radar Scans Distant Sea State

Scientists are monitoring distant sea conditions in the North Pacific for the first time with a specially designed skywave radar that began test operations off the California coast in early summer. Project scientists say that, if the year-long tests of the over-the-horizon system are successful, operational versions of it could speed ships in their transoceanic cruises and could save ocean-related industries, including U.S. fisheries interests, tens of millions of dollars a year. This high-frequency radar is a key element in a cooperative research study known as Sea Echo being conducted by the Naval Research Laboratory (NRL), Washington, D. C., and the Commerce Department's National Oceanic and Atmospheric Administration (NOAA) and Institute of Telecommunication Sciences (ITS), both in Boulder, Colo.

The target area of the first research study is the Gulf of Alaska, selected for its severe and changeable weather, and its role in American energy plans. The Gulf will be crossed by the sea leg of the Trans-Alaska Pipeline, and proposed oil leasing areas on the Alaskan continental shelf are the subject of an intensive environmental study being conducted by NOAA for the Interior Department's Bureau of Land Management. Specifically, the radar-scanning technique employed is capable of helping scientists:

1) predict destructive wave activity along the northwest coast of America;

2) infer average wind conditions near the ocean surface for the prior 6- to 24-hour period;

3) improve warnings to coastal areas and ships likely to be damaged by the waves; and

4) predict where and when high waves will reach other regions.

Weather and sea condition data will be sent for analysis to the Navy's Fleet Numerical Weather Central in Monterey, Calif., and the National Meteorological Center of NOAA's National Weather Service near Washington, D.C. The Fleet Numerical facility and the National Meteorological Center employ automated computer models of global weather which tie together inputs from many sources and produce sea state and weather predictions. The Navy now uses Fleet Numerical predictions for optimum ship routing for savings in transit times and fuel costs.

Remote areas such as the North Pacific are sparsely measured and the Sea Echo data are expected to have a high potential in supplying needed information. Navy and NOAA scientists will test the radar data against the computer-generated models for a year or more to determine its reliability and accuracy before using it in real-time predictions.

Robert W. Bogle, Research Physicist for NRL, categorized the project as one of high technical promise. "Based on our extensive experimental data base and an advanced understanding of the phenomenology, we have been able to design a system which is uniquely suited to the purpose of remote sea sensing," he said. Donald E. Barrick, Chief of Sea State Studies for NOAA's Wave Propagation Laboratory, confirmed this. "It will be the first time," Barrick said, "that it is possible to monitor wave and sea conditions on a regularly scheduled basis by remotely sensing sea state out to as far as 2,000 nautical miles."

A Wave Propagation Laboratory report estimates economic benefits to U.S. interests of tens of millions of dollars a year from an operational, $12 million, two-site sea-scatter radar system scanning both oceans. With full and efficient use of an operational system, the report estimates annual savings of as much as:

1) $45 million by ships carrying U.S. cargoes; 2) $8 million by U.S. fisheries; 3) $16 million by U.S. naval operations and research; 4) $14 million by offshore oil drilling and pumping operations; 5) $5 million by marine scientific research; 6) $4 million from coastal damage prevented; and 7) $8 million by recreation.

The cooperative research program is guided by an interservice group consisting of Bogle, Barrick, Douglass D. Crombie, Director of ITS, and James H. Headrick, Manager of NRL's HF Radar Branch. Crombie is credited with the discovery in 1955 that long wavelength radar had a unique capability to sense the character of the sea. A group of engineers at Crombie's laboratory under Lowell Tveten has built and installed the sophisticated Sea Echo system. Headrick and his NRL group have performed extensive long range sea measurements with their powerful Madre radar, located on Chesapeake Bay. Theoretical and computer-oriented analyses are being done in his organization.

While other government-sponsored and university groups have explored the technology of remote ocean radar

sea sensing, the Navy and NOAA team, by pooling their resources, have been able to put together the only high-frequency (HF) radar expressly designed for this purpose.

The Sea Echo radar, resembling a monster radio station more than a typical radar, stands on a rocky shoreline at the north end of San Clemente Island, a test facility operated by the Naval Undersea Center in San Diego, 90 miles off the California coast. The prominent antenna consists of a 0.25-mile row of 150-foot towers and a spider-web of antenna wires. The sophisticated electronics and a full-size computer are housed in trailers. Because of the remoteness of the site, power is supplied by three diesel generators obtained from a concluded Atomic Energy Commission project.

From its perch on the north end of the island, the 1,200-foot (366-meter) long by 400-foot (121-meter) wide antenna scans a 1,550-nautical-mile (2,500-kilometer) long sector of the North Pacific Ocean and Gulf of Alaska. The radar's signals will be able to observe the coast of California, Oregon, Washington, and British Columbia as well as a wide section of ocean in the Gulf of Alaska. The Sea Echo radar will also be able to "zero in" on any of 400 designated 80 square mile patches of ocean within the antenna's range as far away as the westernmost tip of the Aleutian Island chain.

Unlike the familiar microwave radars operating with short wavelengths and "dish" antennas, the novel radar employed in this project uses very long wavelengths. At these long wavelengths, signals are reflected by the ionosphere to great distances over the horizon. (This phenomenon is familiar to motorists whose AM radios can pick up distant stations, particularly at night.) However, the most important aspect of the long radio wavelengths used is that they exactly match the wavelengths of the ocean. The use of this effect makes the Sea Echo system very sensitive to the conditions of the sea. Some of the sea-scattered radio energy returns to the radar over the same path. A computer at San Clemente records the time delays for the echo return as well as the echo frequencies, and analyzes the way the returning echo has been scattered at the ocean surface. From this information the computer produces contour-line maps showing differing wave heights, directions, and periods within the region scanned with as little as an hour and a half of echo observations.

New York Bight Waste Dumping Study Reports Some Damage But No Immediate Threat

A preliminary report on the life and environment of the New York Bight—a roughly pentagonal 15,000-square-mile area extending from an apex between Long Island and New Jersey to the edge of the continental shelf about 100 miles offshore—concludes that: 1) Despite significant evidence that ocean disposal of wastes off New York has caused some ecological damage, there appears to be no immediate threat to the public health or to Long Island beaches; and 2) Ocean dumping as now practiced there should cease once alternative disposal methods of lesser environmental impact are found.

The National Oceanic and Atmospheric Administration issued its report in mid-summer after 18 months study of the bight. The study is being conducted by the Commerce Department agency's Marine Ecosystems Analysis (MESA) program, part of NOAA's Environmental Research Laboratories. Now in its second year, the 7-year study is designed to provide a comprehensive look at how the New York Bight ecosystem copes with the environmental pressures of a major urban-industrial complex and some 20 million human neighbors.

Soon after its July 1973 start, the MESA New York Bight project began focusing on determining the specific ecological effects of offshore dumping of sewage sludge (a byproduct of wastewater treatment), dredge spoil, waste acid, and other materials at a rate of nearly 10.5 billion cubic feet per year. This is the picture that emerges from the first report.

The area of the New York Bight in which present dumping sites are located is swept by gentle currents along the seafloor, some of them part of an intermittent clockwise gyre that moves water northward toward Long Island, then seaward, then to the southeast across the continental shelf. Little sediment or dumped material is transported over the ocean floor in the dumping site areas except during the passage of major storms, when movement of as much as 1,200 feet has been observed over periods of several days. Water circulation in the area appears to be dominated by tidal currents, freshwater discharges from the Hudson and Raritan Rivers, and seasonal effects which tend to stratify Bight waters. Only in winter is there much vertical mixing in the water column.

There has been essentially no build-up of sewage sludge at the dump site. Sewage sludge is about 95 percent water, and much of its solids content is dispersed, mixed, and diluted as it joins the other suspended sediments which cloud Bight waters. Also, biological and chemical processes continually break down dumped materials. At the dredge spoil dump site, however, a mound of material some 30 feet high has accumulated over about a generation of dumping.

Nutrient levels (nitrogen, phosphorus, and silica compounds) are generally high near the sewage sludge dump, and slightly above "normal" around the dredge spoil dump site. Beyond these localized increases, nutrients in the Bight appear to be controlled mainly by the outflow of the Hudson and Raritan Rivers.

The unsightly black mud popularized as "black mayonnaise" does not indicate the presence of sewage sludge. In fact, the existence of muds in some topographic lows off Long Island is typical of transient muddy patches found along much of the Atlantic coast. There is a small admixture of what appears to be sewage sludge in mud samples taken off Long Island; however, it is not possible to say whether these materials came from the dumping site or from sewage outfalls. There is no evidence that a front of sewage sludge is stalking Long Island beaches, or that ocean dumping in the New York Bight has created an immediate threat to the public health.

Ocean dumping, however, may be a factor in certain observed signs of eco-

system damage. Concentrations of coliform (intestinal) bacteria in Bight shellfish beds appear to be increasing. Last year the Food and Drug Administration expanded the area closed to shellfishing near the dump site. Fish taken from the apex also have a higher incidence of fin rot than specimens taken elsewhere in the Bight. And, crabs and other crustacea in the dump areas show some shell deformities that could be pollution-related.

Antibiotic-resistant strains of coliform bacteria have been found in the Bight, suggesting that this acquired resistance, or "R-factor," is transmitted via harmless as well as harmful bacterial species. The public health significance of this last discovery is not known. "The importance of R-factor transmission among Bight bacteria is an area in which no one has much experience," explains Charles Gunnerson, director of the MESA program. "Next year we'll be emphasizing studies of possible public health impacts. We'll also begin measuring petroleum hydrocarbons in the Bight and try to determine whether 'fallout' from polluted air is a significant contributor of contaminants."

One crucial area of uncertainty, Gunnerson notes, has to do with determining the presence and source of sewage-derived materials taken from the Bight. "There is no way at present to measure sewage sludge in a given bottom sample, or to determine whether the sludge is from the dump site or some other source. There are still important questions as to when sewage sludge becomes something else in the sea. We are using a variety of measurements—trace metals, total organic carbons, and the ratio of total organic carbons to carbohydrates. This last shows some promise as a sludge indicator. Probably we will have to make a number of analyses and take our conclusions where the results of different tests converge."

The effects of ocean dumping are only one facet of the ecological picture NOAA scientists hope to get of the New York Bight. "If dumping stopped today," Gunnerson says, "we would still have a heavily stressed environment there. We're working in a corner of a bathtub. We know some of what we see here is influenced by what goes on elsewhere in the Atlantic. But we don't yet know how to assess the importance of observed effects, whether we should be thinking parts per million or parts per billion."

Meanwhile, NOAA scientists have agreed to help the Environmental Protection Agency study alternative dumping sites offshore, should the decision be to move present dumping farther out to sea.

"All our information points to some ecological damage from present dumping practices in the New York Bight," explains R. Lawrence Swanson, who manages the project from its Stony Brook, N.Y., headquarters. "We think that ocean dumping as it is now practiced in the Bight should stop. Alternatives could be either disposal ashore or additional cleansing of present wastes before dumping them at sea.

"These alternatives will not be available overnight, and because there appears to be no evidence of an immediate health problem or threat to Long Island beaches from dumping, we have recommended that the present dumping sites be kept active until alternatives can be developed.

"But we also want to be sure that any decision to move present dumping farther out into the Bight is guided by solid scientific data. That is why we are looking at alternative areas for the Environmental Protection Agency."

NOAA has urged that any move to alternative dump-site areas be preceded by at least a year of intensive study which EPA and NOAA have underway. In that interval, NOAA scientists hope, a clear picture of the currents, life forms, water chemistry, and bottom composition would permit them to locate the new dump sites where they would do the least ecological damage.

Scrap-Tire Rafts May Protect Shorelines

Use for discarded tires, now accumulating at more than 200 million per year in the United States, has been found by University of Rhode Island engineers. With support from the National Oceanic and Atmospheric Administration's Office of Sea Grant, a team headed by Tadeusz Kowalski, URI associate professor of ocean engineering, has developed a method of assembling scrap tires to form moored, floating breakwaters for protecting small boat marinas and shorelines vulnerable to erosion. "The scrap-tire rafts are not only inexpensive in comparison with conventional fixed breakwaters," according to Kowalski, "but they also are highly effective and ecologically sound."

The university's breakwater development effort, which began two years ago, has been funded by the Goodyear Tire and Rubber Company, as well as by the Commerce Department's Office of Sea Grant. During the 2-year period, the Sea Grant research team has designed, built, and tested three types of scrap-tire breakwaters. "The third design," Kowalski says, "is the simplest and the best." In this version, 18 tires standing on edge are strapped firmly together with stainless steel cable in a roughly diamond-shaped pattern, forming single units to be assembled into larger breakwaters. Each unit, essentially a small floating raft, can be tied together on shore in about 10 minutes. The units are then pushed into the water, where they are strapped together and moored to the bottom. The diamond-shaped rafts can be arrayed in a variety of configurations, depending on the requirements of the site, and the entire breakwater can be moved to meet changing seasonal or other conditions. The resulting breakwater, Kowalski says, can be as large as 500 × 22 feet, and would diminish a 3-foot wave to less than a foot.

Because the tires are set vertically, air is captured in their crowns and only several inches of their tops float above the water surface. The low-lying breakwaters should be well marked to avoid being hit by boaters, Kowalski points out, but the tires' resilience minimizes the possibility of damage to boats if collisions should occur.

One of the first uses of floating breakwaters was at Normandy to protect the allied invasion, but a major storm destroyed that breakwater. Research on floating breakwaters did not resume until the 1960's. Today, pleasure boat marinas have the greatest need for inexpensive floating breakwaters. Most naturally protected harbors already have been developed, so new or expanded marinas require some form of artificial protection.

Fixed breakwaters are expensive, especially if the water is very deep, and may not only interfere with shore processes and fish migration but may also alter the natural pattern of circulation and flushing that maintains good water quality within marinas. "The inexpensive floating scrap-tire breakwaters do not impede tides or natural current flows as fixed breakwaters may," Kowalski says. "Also, because they lie low in the water, they do not destroy the aesthetic values of the marina areas. Furthermore, experiments have shown that pollutants do not leech from the tires." During their tests, the Sea Grant team discovered that the scrap-tire breakwaters created an added bonus for sport fishermen. Seaweed and barnacles begin growing on the tires after a few months, just as they do on artificial reefs, providing food for small fish which soon attract larger fish.

The Rhode Island ocean engineers' latest breakwater design is being used by yacht clubs and marinas in Cranston and Providence, R.I., and Boston, Mass. At Cranston's Edgewood Yacht Club, the cost of the 500-foot breakwater was only $1,500, not counting the labor donated by club members or the tires provided free by tire replacement centers.

Managers of the 1975 Newport, R.I., International Sailboat Show are planning to build a 500-foot scrap-tire breakwater to safeguard the valuable craft on display. Last year, a four-part breakwater—including a 100-foot scrap-tire section constructed and installed by the URI team—was built to protect the show's boats from a north or northeasterly storm.

According to Paul E. Dodson, Jr., President of the Newport International Sailboat Show, the worth of the floating breakwater was dramatically proven when the Newport area was subjected to winds in excess of 20 knots. "The value of the boats and floating docks protected by these floating breakwaters exceeded five million dollars. Without this breakwater protection, damage caused by these winds could well have reached a million dollars," he says.

Now that the university's ocean engineers have completed their experimental work, they will monitor the new breakwaters to see how long they last and whether additional improvements can be made. The present breakwater design is effective only for waves less than four feet high. Kowalski and his group hope to develop a larger floating breakwater for use in the open ocean. "Such a breakwater might be effective for protecting coastal construction sites, oil drill rigs, and oilspill cleanup operations in heavy seas," Kowalski says.

NOAA Assesses Probable Oil Lease Impact on Alaska's Continental Shelf Environment

A Federal effort to assess the environmental risks of developing the offshore petroleum potential of the northeastern Gulf of Alaska has been expanded to cover five other key areas of the northern state's share—about 60 percent—of the nation's total continental shelf area. The multimillion-dollar program, conducted by the Commerce Department's National Oceanic and Atmospheric Administration under the auspices of the Interior Department's Bureau of Land Management, is examining the life forms and physical environment of these additional areas, selected for their petroleum potential: 1) Two areas along the northwest rim of the Gulf of Alaska, one centered off Kodiak Island, the other running southwestward along the Aleutian Shelf to the Shumagin Islands; the present environmental study is continuing in the northeast Gulf of Alaska; 2) two in the broad, shallow shelf area of the Bering Sea: one in St. George Basin, a prominent declivity north of the Aleutian chain; and one in Bristol Bay Basin, between the Alaskan "mainland" and the Alaska peninsula, which becomes the Aleutian chain; and 3) one in the Beaufort Sea, running eastward from Barrow to Alaska's boundary with Canada.

The 4-to-5-year program, which is being managed by NOAA's Environmental Research Laboratories in Boulder, Colo., seeks to provide a basis for predicting the primary environmental impact of petroleum development along the Alaskan shelf. The program is being carried out in concert with other federal and state investigations. These specific questions guide the research program:

1) What are the major biological populations and habitats subject to potential impact by petroleum exploration and development? 2) What is the existing distribution and concentration of contaminants commonly associated with petroleum development? 3) What are the nature and effectiveness of physical, chemical, and biological processes which transport pollutants? 4) What are the effects of hydrocarbon and trace metal contaminants on Arctic and sub-Arctic biota? 5) What is the likelihood and timing of recovery of populations from the effects of development? 6) What hazards does the environment pose to the safety of petroleum exploration and development activities? and 7) What conclusions may be drawn regarding the impact of Outer Continental Shelf petroleum development on the Alaskan marine ecosystem? To answer these questions, NOAA is drawing upon the expertise of its own scientists, and those in other Federal and State of Alaska agencies and in several universities.

Over the first two years of the program, investigators will be intensively studying Alaskan marine ecosystems. The marine food web from birds and mammals to planktonic life forms and marine microbes is being censused, and their pathologies determined. Scientists are attempting to define the peculiar adaptations of these life forms to their northern environment, and their susceptibilities to contaminants. Efforts are also being made to determine the role played by regional life forms in transporting, storing, and breaking down some hydrocarbon and trace-metal contaminants.

Alaskan waters are being investigated in detail, to determine how natural circulations, sediment transport, and other processes affect life there, what role these processes play in spreading contaminants from a site of petroleum development, and what natural hazards face oil development activities.

According to Wilmot N. Hess, director of NOAA's Environmental

Research Laboratories, the Alaska investigations present formidable logistical and operational problems. "These studies are taking us into some of the most difficult weather and terrain on earth," he says, "in areas about which relatively little is known. In terms of operating ships, aircraft, and land teams, it is comparable to the North Sea."

Each area will bring its unique set of problems. Along the Gulf of Alaska branches of the project, scientists are studying the comparatively narrow shelf which terminates at its southwestern end in the deep Aleutian Trench, one of the world ocean's major bathymetric features, in the ring of intense earthquake activity which borders the Pacific. Biological investigations are quite intensive throughout, but with special emphasis on the possible impacts of oil development on marine life in the Bering Sea and Bristol Bay areas. These are among the most biologically productive waters in the world.

Farther north, the investigations are being complicated—and finally will be dominated—by low temperatures and sea ice. "I think we have eight to ten years before possible oil and gas production activities along the Outer Continental Shelf of Alaska could be environmentally significant," Hess explains. "We hope in this time to develop an understanding of the undisturbed ecosystem and learn a great deal about the effects of oil under conditions unique to Arctic and sub-Arctic regions." "The value of this kind of work will be to help shape the regulations and operating orders which will govern what oil developers do here, and how they do it."

Seeding Technique Restores Bay Bottom

A University of Miami Sea Grant scientist, using a new seeding technique, has restored vegetation on a bay bottom denuded by heated water and silt from a power plant. Since the release of these effluents into Biscayne Bay ended, Anitra Thorhaug has succeeded in growing *Thalassium testudinum*—commonly called turtle grass because it is a favorite food of sea turtles—on the bay's bare floor. Her research is supported by the National Oceanic and Atmospheric Administration's Office of Sea Grant. In addition to the Commerce Department agency, the Florida Power and Light Company and the Atomic Energy Commission have helped finance the studies.

"Where turtle grass is, the fish are," Thorhaug says. "It provides food and protection for sport and commercial fishes during various stages of their life cycles. Fishermen know that one of the best ways to catch sea trout, for example, is to allow their boats to drift across carpets of turtle grass, trailing live shrimp as bait."

A vital part of bay ecosystems, seagrasses have been destroyed in many areas by dredging, siltation, and pollution. Earlier attempts to restore turtle grass, by cutting springs of *Thalassia* and planting them in new areas, met with limited success. And, if this technique were carried out on a large scale, it would damage the beds from which the springs were cut. Thorhaug had a new idea: Why not plant seeds of the turtle grass? So she took a diving crew to the Bahamas where, wearing scuba gear, they harvested 8,000 *Thalassia* fruits. Back at the University of Miami's Rosenstiel School of Marine Science, the crew separated 20,000 seeds from the fruits. Then the seeds were treated with root-growth hormones and suspended in running sea water until they could be planted by divers.

The divers planted the seeds in rows, anchoring them with brightly colored plastic. The seeds sprouted roots almost immediately after being planted and grew rapidly. Nine months after the diving crew had jabbed them into the bay floor, only 31 percent of the plants were dead, dormant, or missing.

Thorhaug estimates that her seeding technique can restore seagrasses 10 to 12 times faster than natural processes. It could hasten the comeback of vegetation in underwater lands blighted by dredging, siltation, chemicals, or sewage and could be used to grow seagrasses on underwater banks or canal sides. But much research remains to be done, she notes. The stresses placed on the young plants by fluctuating water salinity and temperatures must be evaluated. In the meantime, Thorhaug's diving teams are planting turtle grass seeds in an area of Biscayne Bay, between Miami and Miami Beach, where siltation and pollution long ago thinned out bottom vegetation and where few fish cruise.

Malaysian Prawn Culture Studied

A large, succulent crustacean from Malaysia could join shrimp and lobster in popularity with America's seafood consumers, if the efforts of South Carolina Sea Grant scientists are successful. With support from the National Oceanic and Atmospheric Administration, specialists at several South Carolina institutions are working together to develop successful techniques for cultivating the giant Malaysian prawn, *Macrobrachium rosenbergii*, in captivity.

Paul Sandifer of the South Carolina Marine Resources Research Institute, Charleston, heads the Commerce Department agency-sponsored project. Associated with him in the Institute effort is Theodore Smith, mariculture specialist. "In appearance, size, and flavor," Sandifer explains, "the Malaysian prawn lies somewhere on a scale between the shrimp and spiny lobster. Most important of all to the prospective grower, the prawn is known to reproduce and prosper in captivity."

Last spring and summer, the scientists stocked five outdoor freshwater ponds with about 25,000 laboratory-reared postlarval prawns. When the ponds were harvested three to five months later, 60 to 70 percent of the prawns had survived and grown substantially. The size of the harvested prawns varied, depending on their size when stocked and the length of time they lived in the ponds. The largest prawns harvested weighed more than an ounce. One pond, stocked with very small juveniles weighing about 0.01 ounce, yielded the equivalent of nearly 600 pounds of prawns per acre after only four months. The pond stocked with the largest prawns—averaging 0.1 ounce in weight—produced a yield equivalent to 1,400 pounds per acre after five months.

Artificial culture of creatures of the sea requires development of complex,

interdependent systems and techniques —tanks, circulating water systems, special diets, and methods of hatching and raising larvae to the adult stage. In the South Carolina Sea Grant project, Paul Zielinski and Walter Castro, engineers at Clemson University, have experimented with two types of tanks for rearing the prawn larvae. Their studies not only are advancing the design of tanks, but are also providing new information on circulating patterns within the tanks and on the use of small air-lift pumps. They have found that existing information on air-lift pumps does not apply to the small pumps that lift water less than 15 feet to provide circulation in culture tanks. Their efforts to fill this information gap will have wide application outside the field of aquaculture.

South Carolina's cooperative Malaysian prawn culture program includes two additional projects. John Manzi of the College of Charleston is investigating the value of algae-rich "green" water as a supplemental food source for prawn larvae. Jeanne Joseph of the Marine Resources Institute is studying the fat content of cultured prawns and the influence of diet on this content.

Pilot-scale commercial aquaculture of the species in the United States began in Hawaii and is now underway at several other locations in the United States. Related Sea Grant supported projects are being conducted by the University of Georgia, Hawaii's Department of Land and Natural Resources, University of Hawaii, Florida Atlantic University, and the Micronesian Mariculture Development Center at Palau in the Pacific Trust Territories. The South Carolina Sea Grant investigators are adapting much of the existing culture technology to the State's environment, improving and refining the techniques to fit local conditions. To develop prawns suitable for South Carolina's temperatures, two species of *Macrobrachium* that occur naturally in the state may be hybridized with the Malaysian import. If appropriate culture techniques can be perfected and adopted by industry, prawn growing would provide a new source of income for local residents and a significant new source of high-quality protein. At the Marine Resources Research Institute, postlarval Malaysian prawns are being produced routinely on a laboratory scale. A new hatchery facility now being developed will provide animals for all investigators participating in the program.

Foreign Fishery Developments

Soviet Fisheries Research Submarine, *TINRO-2*, Ready for Serial Production

A miniature Soviet fisheries submarine, used in studying the biological resources of the Continental Shelf, has completed a series of tests in the Black Sea and in the Atlantic Ocean, according to *Vodnyi Transport*.

The sub *TINRO-2* was designed to study fish, underwater plants, and mineral deposits at depths up to 300 meters (about 1,000 feet). It is equipped with navigational and hydroacoustic instruments as well as with television and automatic still and movie cameras. The two-man crew includes a pilot, who serves as the commander of the vehicle, and a research scientist who may be an oceanographer, ichthyologist, or marine geologist depending on the nature of the expedition. *TINRO-2* was designed by "Giprorybflot," the Soviet Federal Design Institute of the Fishing Fleet, primarily for use by the USSR Ministry of Fisheries.

In September 1974 the testing of *TINRO-2* in the Black Sea was completed: in 81 days at sea a total of 29 dives were made. The *Ikhtiandr*, *TINRO-2*'s mothership, left the Black Sea for the Atlantic Ocean carrying the submarine on board in a sort of a "hangar." The two vessels spent about half a year in the Atlantic continuing tests and trial dives. According to *Tass*, *TINRO-2* and the *Ikhtiandr* made two complete crossings of the Atlantic in 160 days, studying bottom structure, fish behavior, and plankton distribution. More than 50 dives were made to depths of 200-400 meters.

By April 1975, both vessels had returned to their home port of Kerch' on the Black Sea. From Kerch' *TINRO-2* is to be shipped to Leningrad to be displayed at "Inrybprom-75," an international exhibition of fish-processing machinery, equipment, and fishing vessels, to be held 6-20 August 1975. Meanwhile, serial production of the *TINRO-2* class of miniature fishery submarines is about to begin.

The Office of International Fisheries, NMFS, NOAA reports that "serial production" of the fisheries mini-submarine vehicle indicates that its prototype performed satisfactorily during the shake-down cruise. In 1960, Soviet underwater research scientists also planned the construction of a larger sub with an independent surface cruising range of 600 miles. This vessel, to be known as *TINRO-1*, would need no mothership and could remain submerged up to 20 days. Because of the large inside space, it could be equipped with a wide range of research instruments. A system of lock chambers with double doors would allow divers to leave the submerged vessel to conduct experiments under water. The 7-man crew, including a researcher, pilot, and engine mechanic, would work in two shifts. However, although *TINRO-2* has already gone into serial production, *TINRO-1* seems to have remained more or less "on the drawing board."

TINRO-1 and *TINRO-2* are alike in name only. The vessels, as already described, are very different in structure and operation. *TINRO-2* is small and dependent on a mothership, while *TINRO-1* is larger and built to cruise independently. Both of these underwater research vessels were originally planned for use by the Soviet Pacific Research Institute for Fisheries and Oceanography, whose initials in Russian spell "*TINRO*." Located in Vladivostok, this facility serves as the base

of operations for Soviet fisheries research conducted in the Pacific Ocean. In spite of the fact that *TINRO-2* has been tested so far only in the Black Sea and the Atlantic Ocean, she may still be assigned to the Institute in Vladivostok.

On 25 February 1975, the *Ikhtiandr* and *TINRO-2* were sighted by National Marine Fisheries Service enforcement agents about 40 miles east of Miami off the Grand Bahama Banks. *TINRO-2* was observed in the waters near the *Ikhtiandr*, and it is believed that exploratory and research investigations were in progress. Both vessels were later reported off the Mexican coast on Campeche Banks.

Taiwanese Fish Catch Drops Sharply in 1974

The Republic of China's (Taiwan) fish catch in 1974 totaled 697,800 metric tons, a sharp reduction of about 60,000 tons from the 1973 output of 758,000 tons. The decline was attributed primarily to the reduced deep-sea catch, which fell 45,000 tons below the previous year's figure. The decline also ended the 3-year upward trend that had marked Taiwan's fish production (1971, 650,000 tons; 1972, 694,000 tons; and 1973, 758,000 tons). The tuna catch recorded 99,700 tons, comprising one-seventh of the total. Other important catches included shrimp (47,000 tons), shark (36,800 tons), sardine (36,700 tons), and cutlassfish (34,500 tons).

Source: *Suisan Keizai Shimbun.*

Korea Proceeding with Moroccan Fish Investment

The June 1974 fisheries agreement obligating the Republic of Korea (ROK) to invest US$13 million in the development of Morocco's fishing industry is being actively implemented according to a report in *La Vie Economique*, Rabat, Morocco.

Five companies have been established to carry out the agreement. The Société Générale Marocaine de Pêche (SOCEP), located in Agadir, is already in operation. The other four companies are: the Société de Pêche Maroco-Coréene (PEMACO), the Société Dongwon de Pêche, the Fisheries Corporation of Morocco and Korea (FIMACO), and the Compagnie Internationale de Pêche et d'Armement (CIMPA). All are close to the start of operations. The Moroccan part of the agreement is under the supervision of Dahmane Layachi, the Director General of the Moroccan Office of Fisheries (Office National des Pêches).

India's Fishery Exports to U.S. Increase in 1974

India's fishery exports to the United States increased both in quantity and value from 1973 to 1974 (see Table 1). The increase in value (from $19.8 million to $33.7 million, or 70 percent) was greater than the increase in quantity (from 10,235 metric tons to 14,633 tons, or 43 percent), an indication that Indian exports benefited from the world-wide increases in the price of fishery products, notes the Office of International Fisheries, NMFS, NOAA.

The largest single export commodity was shrimp, representing about 91 percent of the total quantity of Indian fishery exports. The largest amount of shrimp exports were peeled, but otherwise unprocessed (except for freezing). The average price of "peeled raw" shrimp exports increased by 5 percent (from $0.81 per pound to $0.85 per pound). This rise was far below the price increases which several other countries commanded in their shrimp exports to the United States; for instance, in 1974 while Panama's exports to the U.S. declined from 10.4 million pounds (1973), to 10.1 million pounds, the value increased from $1.61 per pound (1973) to $2.39 per pound in 1974 (a 48 percent increase); Mexico's exports to the U.S. increased from 76 million pounds valued at $1.46 per pound in 1973, to 78 million pounds valued at $1.84 per pound in 1974 (a 27 percent increase).

The lower average prices of Indian shrimp indicate the quality control problems which beset the Indian shrimp exports to the United States. The U.S. Food and Drug Administration has repeatedly impounded large amounts of Indian shrimp, primarily because of decomposition.

Table 1.—India's fishery and related exports to the United States by quantity and value for 1973 and 1974[1].

Commodity	1973 Quantity (lb)	1973 Value (US$)	1974 Quantity (lb)	1974 Value (US$)
Fish				
Cod blocks	29,898	21,972	—	—
Other blocks	184,905	80,198	85,150	63,238
Fish, frozen	—	—	3,100	1,767
Fillets	7,440	2,827	—	—
Fish, dried-unsalted	—	—	243	407
Fish, smoked	—	—	400	320
Canned fish	—	—	364	643
Total, fish	222,243	104,997	89,257	66,375
Shellfish				
Crabmeat	—	—	1,155	1,772
Lobster, live	—	—	4,050	5,640
Rock lobster tails	1,096,829	1,633,221	651,322	1,503,863
Lobster, n.o.s.[2]	66,189	91,099	132,990	273,013
Scallops	—	—	25,022	21,361
Shrimp, shell on	2,255,749	2,564,615	4,068,052	6,730,821
Shrimp, canned	1,715,788	1,494,163	3,352,571	3,560,850
Shrimp, peeled raw	16,561,237	13,360,222	23,958,277	20,408,329
Total, shellfish	21,695,792	19,143,320	32,193,439	32,505,649
Other fishery products	599,819	514,618	1,345,476	1,100,563
Grand total, fish products	22,517,854	19,762,935	33,628,172	33,672,587
Frogs				
Frogs, n.o.s.	3,306,456	3,452,367	3,658,864	5,306,273
Frogmeat	23,650	19,734	15,700	22,933
Total, frogs	3,330,106	3,472,101	3,674,564	5,329,206

[1]Source: U.S. Bureau of the Census.
[2]Not otherwise specified.

Additional agreements were reached in November 1974, during a visit to Rabat of Dong Soo Kim, the former Director of the ROK Office of Fisheries. These agreements included the sending of two Korean aquaculture specialists to Morocco and the establishment of 10 scholarships, five of which will be financed by the Korean Government. The two Governments are reportedly discussing a further broadening of the existing agreements.

Spanish Fishery Imports and Exports Compared

Spain imported 183,000 metric tons of fishery products in 1963, about 6 percent less than 5 years earlier when her imports reached almost 195,000 tons (Table 1), the Office of International Fisheries, NMFS, NOAA reports. The exports, on the other hand, increased during the same period from 133,000 tons to 188,000 tons—41 percent.

An even more significant shift occurred during the 1969-73 period in the relative importance of various commodities traded. The imports of fish meal, for example, decreased by 73 percent (from 141,000 tons in 1969 to 38,000 tons in 1973), while the imports of fresh and frozen fish increased by 260 percent (from 14,000 to 52,000 tons). Similarly, the imports of fresh and frozen shellfish quadrupled from an estimated 12,000 tons in 1969 to over 60,000 tons in 1973.

The improved fishery balance of trade is the direct result of a large expansion and modernization of the Spanish fishing fleet, which now ranks third in the world in terms of gross registered tonnage (after the Soviet Union and Japan). This made possible a larger catch. During the last decade (1964-1973) the Spanish catch increased from 1.2 million metric tons to about 1.6 million tons.

Table 1.—Spanish fishery exports and imports, in metric tons, 1969 and 1973.

Commodity	Imports		Exports	
	1969	1973	1969	1973
	metric tons			
Fish				
Fresh fish	4,910	11,495	2,199	4,042
Tuna and tuna-like, frozen	4,983	6,119	2,612	11,426
Other fish, frozen	4,556	34,660	6,478	15,797
Total, fresh or frozen	14,449	52,274	11,289	31,265
Salted and dried cod	5,832	8,021	48,883	26,148
Salted and dried cod-like	[1]	10,218	[1]	11,841
Salted anchovy	620	3,851	8,490	3,426
Other fish, cured	428	1,038	2,834	3,581
Total, cured	6,880	23,128	60,207	44,996
Canned anchovy fillets	1	1	4,321	4,511
Canned sardines	7	9	17,914	28,978
Canned tuna and tuna-like	—	2	3,163	2,786
Other fish, canned/processed	327	670	4,271	3,122
Total, canned/processed	335	682	29,669	39,397
Total, fish	21,664	76,084	101,165	115,658
Shellfish				
Mussels, fresh	—	—	8,107	9,420
Cephalopods, frozen (squid, etc.)	[2]	27,148	[2]	48,330
Other shellfish, fresh/frozen	12,297	33,051	16,899	1,264
Total, fresh/frozen shellfish	12,297	60,199	25,006	59,014
Mussels, canned	34	3	1,976	4,347
Cephalopods, canned	—	—	1,976	2,846
Other shellfish, canned	789	2,667	531	539
Total, canned shellfish	823	2,670	4,483	7,732
Total, shellfish	13,120	62,869	29,489	66,746
Marine oils	18,699	6,163	2,497	3,905
Fish meal	141,427	37,807	49	1,981
Grand total	194,910	182,923	133,200	188,290
Percentage of increase or decrease		−6.2%		+41.4%

[1]Not given separately: probably combined with salted and dried cod.
[2]Not given separately, but considerably less than in 1973.
Source: Ministerio de Hacienda. Direccion General de Aduanas. *Estadistica del Comercio Exterior de España*, Madrid 1969 and 1973.

Morocco Seizes Spanish Ships in Contested Seas

A Moroccan patrol launch seized two Spanish trawlers on 7 April in waters close to the median line dividing the two countries' respective coastlines reports the Office of International Fisheries, NMFS, NOAA. The Mediterranean Sea is 65 miles wide at the point of seizure, and Morocco claims a 70-mile Contiguous Fishery Zone, excluding however, the Strait of Gibraltar. Spain does not recognize the 1973 law by which Morocco extended its Territorial Sea and fishery limits.

The first fishing vessel was released within 2 hours when a Spanish destroyer arrived on the scene, but the second was forced to proceed to Tangier when a Moroccan sailor aboard the Spanish trawler threatened to kill her captain. On 10 April, a Spanish frigate sailed to Tangier to return the two Moroccan sailors captured on the first Spanish fishing vessel. In exchange, the seized Spanish trawler, with its crew, was allowed to depart the Moroccan port without payment of a fine.

Both Governments were eager to avoid an escalation of tensions as they are negotiating agreements on a number of sensitive issues. Several other Spanish fishing vessels are reportedly languishing in Moroccan ports pending disposition of their cases.

Rising Costs Mar Future of Peru Anchovy Fishery

The official fishing season for anchovies in Peru closed on 15 May 1975. Some experimental fishing, to determine the status of the resource, followed the closing and the total catch by 5 June amounted to about 3 million metric tons. It is believed that Pesca Peru (a state-owned corporation) will catch a total of about 5 million tons of anchovy in 1975. The extent of future anchovy fishing is clouded by the rising cost of fish meal production. The U.S. Embassy in Lima estimates that the

cost of production is currently about $230 per ton. Substantial increases in the cost of fuel and labor are expected to further escalate the costs of production.

Fish meal stocks as of mid-summer 1975 were estimated at about 500,000 tons. New fish meal sales are believed slow despite Peruvian efforts to enter into contracts with the Socialist countries. Small forward sales to the USSR and Bulgaria appear to lack firm prices. A 450,000-ton contract with West Germany was reported, but 350,000 tons of this appears to be only an option for next year.

France Finds Tuna Export Problems

France requested the European Economic Community (EEC[1]) Council in Brussels to declare a ban on all tuna imports into the EEC earlier this year as the country was having trouble exporting a sizeable portion of its domestic tuna catch, *Le Marin* reports. Were that done, France could have disposed of excess frozen tuna holdings (over 10,000 metric tons) by exporting them to other Common Market countries.

The Council rejected the French proposal as other EEC nations (such as Italy and Germany[2]) have the processing capacity to handle larger tuna imports than France is capable of supplying. The Council, however, moved to take measures to assist the French in the shortrun. A ban on non-EEC tuna imports into France was expected to be extended from 1 July to 1 August and an additional US$5 million may be appropriated to subsidize cold-storage costs of private companies in Common Market countries. The Council also intended to begin discussions with Japan, the Republic of Korea, and Spain with the hope of obtaining agreement on higher export prices for tuna coming into the EEC.

[1]Also known as the Common Market.

[2]Italy's tuna processing plants can absorb about 90,000 metric tons of frozen tuna a year. The French are exporting only about 25,000 tons of frozen tuna per year.

Sweden Expands Marine Science Programs

The Swedish Government is expanding the scope of its marine science programs according to the U.S. Embassy in that country. Although Sweden has 14,000 kilometers of coastline on the Baltic and North Seas, it is only recently that the concern over increased pollution, and possibilities of finding oil deposits in the Baltic, have stimulated the interest of government agencies and private companies in marine affairs.

The Government does not have a central coordinating agency for marine research and development, and the existing 18 governmental organizations are under the control of six different ministries (see Figure 1). The budget for 1975-76, however, includes funds for the establishment of a national Commission for Marine Research and Development as a coordinating agency for all government and private marine research programs.

In 1969, the last year for which there is complete data, there were 88 different public institutions concerned with marine research. Among these were more than 53 university institutes. The amount of Government funds allocated to marine research and development in 1969 was 32 million Swedish kroner (US$6.2 million). At present, the principal areas of marine research are marine meteorology and climatology, marine geology, marine biology, naval medicine, and oceanography and ocean technology.

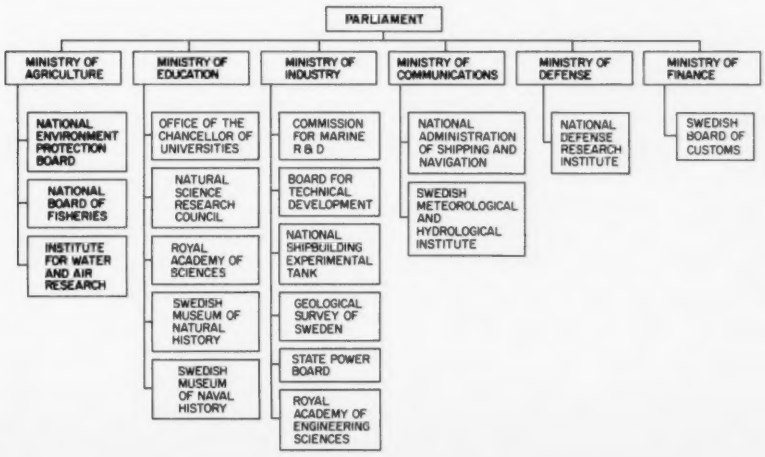

Figure 1.—Governmental marine research and development organizations in Sweden.

French Fishing Vessel Construction Reported

In 1974, French shipyards began the construction of, or delivered 15 large trawlers (5,472 GRT) and 11 tuna seiners (7,473 GRT), according to *La Pêche Maritime*. French fishing companies have ordered two trawlers each, and the Ivory Coast has ordered four seiners. This data does not include the construction of fishing vessels in numerous smaller shipyards which produce small craft for French coastal fisheries. A more detailed breakdown of the tuna seiners is given below.

Tuna vessels delivered, launched, or under construction in French shipyards during 1974.

Vessel name	GRT	Company	Flag
Delivered			
Ile-Aux-Moines	750	Genepêche	France
Mervent	608	Kuhn-Ballery	France
Laurent	555	Grand Lahou Atl. Fisheries	Ivory Coast
Kelerenn	260		France
Total	2,173		
Launched			
F-de Magellan	900	SIPAR	Ivory Coast
Ile Tristan	900	A.C.A.F.	France
Belier	600	SIPAR	Ivory Coast
Cap Bojador	600	Le Garrec	France
Total	3,000		
Under construction			
Jacques Cartier	900	Grand Pêche	France
Gevred	600	Kuhn-Ballery	France
N'Zida	600	Grand Lahou	Ivory Coast
Total	2,100		

FAO Lists 1974 Fishery Activities

FAO's activities in fisheries during 1974 included participation in the third UN Conference on the Law of the Sea which foreshadowed expected changes in marine areas under national jurisdiction or the establishment of exclusive economic zones.

A review of world fish exploitation was submitted by FAO to the Law of the Sea Conference. It indicated that in 1973 the total world catch increased—apart from the Peruvian anchovy catch, which fell again after the decline in 1972. Many of the more attractive species such as lobsters, shrimp, and larger tuna, and the more abundant shoaling pelagic, or mid-water, fish are fully, and in some cases overexploited. The introduction of drastic management measures appears to have helped the recovery of species which had suffered depletion in the Atlantic (menhaden, sardine) and off the coast of British Colombia (herring).

In 1974, FAO operated 89 fishery projects employing 213 experts and funded mainly by the UN Development Program (UNDP). Contributions under bilateral programs increased steadily and will show a sharp rise in 1974-75 with the donation of Can. $2.8 million by the Canadian International Development Agency to the South China Sea Program. Work on this program has started in Manila.

The Eastern Central Atlantic project for the development and rational management of fish resources in an area stretching from Gibraltar to the mouth of the Congo River became operational in 1974. The present annual catch for the region is about 3 million tons, and the project aims at increased fisheries participation by the African States, promoting cooperation between the latter and other nations that fish the area, and assistance in training personnel and improving facilities. The 4-year project will receive over 1 million dollars from the UNDP, another million dollars from Norway, and substantial contributions in kind from African countries. Canada, Cuba, France, Italy, Japan, the Republic of Korea, Poland, Spain, and USA have expressed their willingness to help.

The Indian Ocean Program (IOP), supported by the Norwegian Development Agency and UNDP, completed arrangements for an acoustic survey from Somalia north of Mogadisciu to Pakistan, starting early in 1975. Norway's substantial contribution to this undertaking includes a 400-ton vessel, the *Dr. Fridtjof Nansen*, which was commissioned in October and has been made available to FAO. In conjunction with the Swedish Development Agency (SIDA), the IOP sent a mission to study investment and development opportunities for fisheries in Bangladesh, India, Malaysia, Sri Lanka, and Thailand.

The trend towards regional projects gained impetus during 1974. While increased production may be expected from large industrial fleets, it should also be achieved by improvements in small-scale fisheries operating on an artisanal or individual basis. FAO's plans for regional projects assisted by highly mobile teams of specialists who would help governments to establish fishermen's cooperatives, set up training programs, and introduce appropriate fishing practices have been endorsed by UNDP and the development agencies of industrialized countries. Prevention of waste is one of the objectives, by improving storage, processing and marketing facilities.

Preparations are under way for a World Conference on Aquaculture—or fish farming—to be held in Japan in 1976. Increased output from this source might eventually exceed 40 million tons yearly if governments are willing to provide resources and facilities for research and set aside areas for breeding. Meanwhile FAO has sponsored the preliminaries of a draft convention based on the work of the European Inland Fisheries Advisory Committee and designed to avert the spread of communicable fish diseases to which aquaculture might give rise through international traffic in live fish and fish eggs.

Consultations were organized by FAO to explore the feasibility of harvesting unconventional or unfamiliar species, such as the Atlantic krill, which require promotional support in order to gain acceptance as food by the general public. Concerted action against indiscriminate fishing and pollution included the preparation by FAO of a convention sponsored by the General Fisheries Council for the Mediterranean to protect the living resources of that sea.

Well established fishing industries received FAO help in exploring investment opportunities in developing countries and with cooperating in surveys and pilot operations. FAO assisted in the negotiation of agreements enabling local enterprise to draw on the skill and experience of developed countries.

The ninth session of the Committee on Fisheries took place in Rome and was attended by 71 FAO member countries, the USSR, and ten international organizations. It stressed the need for increased fish production in the developing countries and the importance of training and education in all aspects of fishery activities.

Source: *FAO in 1974.*

Morocco Enters Tuna Fishery

Morocco's first high-seas tuna vessel, the *Tarfaya*, returned to Casablanca with 250 metric tons of frozen yellowfin tuna during the week of 12-18 May 1975, according to a report in *Le Marin*. The tuna varied in weight from 40 to 80 kilograms each. The vessel had also unloaded 150 tons of frozen tuna in the port of Safi, Morocco, before reaching Casablanca.

The *Tarfaya* was purchased by the Maropêche company in late 1974 and was sent to the Gulf of Guinea in November 1974. During its fishing season in West Africa, the vessel landed 851 tons of tuna in Abidjan, Ivory Coast.

Japan Tuna Fishery Bankruptcies Mount

Severe management difficulties confronting Japanese distant-water tuna vessel owners are resulting in mounting cases of bankruptcy, vessel tie-ups, and curtailment of business, according to the *Suisan Keizai Shimbun*.

Estimates based on studies made by Japan's Fisheries Agency, lending institutions, and industry indicate that, as of the end of April 1975, there were 36 cases of bankruptcy involving 56 vessels, 23 cases involving 24 vessel tie-ups, and 40 cases of business curtailment affecting 53 vessels, totaling 99 cases and 133 vessels. In addition, about 101 enterprises are threatened with bankruptcy. The removal from the fishery of over 10 percent of the high-seas tuna fleet (of about 1,200 vessels) is indicative of the grave crisis confronting the Japanese fishing industry.

Although tuna imports from South Korea have contributed partly to the plight of the Japanese tuna vessel owners, the Fisheries Agency's view is that the problem was the outcome of weakening management structure compounded by the energy crisis that struck the industry. The Agency, which in 1974 had provided 9 billion yen (US$30 million) to help the tuna industry recover from the energy crisis, has declared that steps will be taken to aid the industry, but no specific measure has yet been developed.

Publications

New Manuals Promote Seafood Quality

The production of fresh and appealing seafood products requires strict quality control, say Texas A&M University Sea Grant Marine Advisory Services specialists. To help insure high seafood quality, they have produced three seafood quality control manuals, two of which are bilingual.

The first, **Seafood Quality Control: Processing Plants,** is designed to help plant managers recognize sources of bacterial contamination, while making recommendations for improved handling practices and product environment after harvest.

Seafood Quality Control: A Manual for Processing Plant Personnel, a bilingual English/Spanish booklet, stresses the importance of sanitary precautions by employees.

Seafood Quality Control: Vessels/ Embarcaciones, covers handling of seafood between harvest and delivery to the processing plant. Condition of the deck and handling the product on the deck, the hold, and in storage are discussed and vividly illustrated in this bilingual edition.

The seafood quality control series, authored by Ranzell Nickelson, III, and translated into Spanish by Manuel Pina, Jr., is available without charge from the Sea Grant Program, Texas A&M University, College Station, TX 77843.

Mexican Fisheries Publications Listed

The Mexican National Fisheries Institute has issued a bibliography of its 1973-74 publications (in Spanish). The Institute is the Government agency responsible for coordinating fisheries research in Mexico. The studies deal primarily with certain fish and shellfish (sardine, anchovy, shrimp, abalone, lobster, turtles, mackerel, tilapia and snook), other marine resources (ichthyoplankton and seaweed), vessels and gear, and a number of general articles on the present state and development of the Mexican fishing industry. Anyone interested in obtaining a copy of the 3-page bibliography should write: Dennis M. Weidner, Office of International Fisheries, F41, NMFS, NOAA, Commerce Department, Washington, DC 20235.

Impacts of Offshore Oil Forecast in URI Report

Offshore Petroleum and New England, a report of the potential on-shore impacts of oil development on Georges Bank, is available from the University of Rhode Island Sea Grant Program. Author Thomas A. Grigalunas, URI resource economist, estimated impacts from high and low off-shore finds, high and low prices for oil and gas, and one and three regional refineries. The economist said development of a large oil find in the Georges Bank area would not go far in alleviating New England's employment or energy problems, but that a large find could eventually make the region self-sufficient in natural gas and provide substantial employment in selected coastal areas.

The 118-page report contains chapters on hypothetical production from Georges Bank; potential offshore petroleum and refinery investment; regional economic impacts; estimates of offshore oil and gas pipeline transportation costs; and estimates of possible royalties. Copies may be obtained for $5 each from the Marine Advisory Service, University of Rhode Island, Narragansett Bay Campus, Narragansett, RI 02882. Checks should be made payable to the University of Rhode Island.

FAO Publications Catalog Available

Publications on nutrition, commodity production and marketing, world agriculture, plant and animal sciences, food additive control, forestry, and fisheries are described in the Food and Agriculture Organization of the United Nations' fully annotated catalog of publications. The 99-page catalog lists all in-print titles, including series publications, monographs, manuals, maps and atlases, periodicals, statistical compilations, and standard international reference works.

Also available is an illustrated FAO filmstrip catalog describing standard single- and double-frame filmstrips on nutrition, crop cultivation, fertilizers, animal husbandry, irrigation, farm equipment, agricultural extension training, and public health. The catalog of publications and the filmstrip catalog are available free on request from Unipub, Box 433—Murray Hill Station, New York, NY 10016.

Sea Lampreys, Chitosan, and an Experimental Oyster Harvester

. . . .**Sea lamprey control,** as part of a long-range Lake Ontario salmonid development plan, has been resumed with the toxicant TFM in several New York streams according to that state's Department of Environmental Conservation. Lampreys have been a "serious limiting factor on fish survival" but substantial control results were reported in 1974 when survival and sport fishing of stocked salmonids improved significantly over earlier years. . . .

. . . .**Chitosan, a derivative of chitin,** has been successfully turned into transparent film which might find use as dye acceptors, food wrappers, and possibly as artificial skin for burn treatment, the Massachusetts Institute of Technology reports. The film is said to be edible, biodegradable, and relatively strong. The MIT Sea Grant study is aimed at finding an economically acceptable alternative to dumping untreated shellfish carcasses. . . .

. . . .Commercial applications are predicted for **a new two-man experimental oyster harvester** tested earlier this year by Virginia Institute of Marine Science scientists. A rectangular steel-box harvester head with two steel cylinders holding rows of flexible steel tines has been affixed to a 35-foot escalator system from a conventional Maryland-type soft clam harvester. The unit can lift oysters 15 feet from planted bottoms at rates up to one bushel per minute. As the box slides on steel runners, the tined cylinders, turned by an underwater motor, loosen oysters and shells. They are then washed onto the escalator and carried to the surface. . . .

. . . .Considered a nuisance in some countries, **the giant perch, *Lates calcarifer*, is being considered for commercial aquaculture** in Australia where it is a popular food and sport fish, according to *Australian Fisheries*. In breeding trials, scheduled by a private company, the fish will be subjected to light, temperature, and salinity stimulation simulating tropical wet season conditions. Various hormone compounds will also be tested. The species is widely distributed through the Indo-West Pacific region and inhabits swamps and rivers. . . .

. . . .**The Duplin River Estuary on** the southern end of Sapelo Island off the Georgia coast has been proposed by that state as an estuarine sanctuary the Commerce Department reports. This would permit the area to be maintained in its natural state for scientific and educational purposes. If accepted, Federal funds could be used to help purchase about 5,800 acres of marshland and high ground; the State of Georgia would provide 50 percent or more of the cost of acquisition and development. The estuary is ecologically typical of the Carolinian biogeographical

classification of estuaries along the South Atlantic coast and contains several miles of tidal salt marsh as well as estuarine and tidal creek systems. . . .

. . . .That the **green sea turtle's (*Chelonia mydas*) long oceanic migrations** are closely related to ocean current systems has been postulated by Joseph D. Richard, associate professor of biological oceanography at the University of Miami's Rosenstiel School of Marine and Atmospheric Science. Some of these currents, driven by changing wind patterns, are seasonal and, Richard says, turtles would need only to respond to some aspect of the changing seasons to stop feeding on the shallow grass beds and start drifting. Further research is being conducted to test this passive drift hypothesis. Richard's thesis contradicts the widely-held belief that green sea turtles use a sense of navigation to return to their nesting beaches. . . .

. . . .**Nine students of the School of Fisheries,** Escuela Superior Politecnica del litoral, Guayaquil, Ecuador, have been awarded 4- and 6-year fishery scholarships to study in the Soviet Union, the NMFS Office of International Fisheries reports. Five students will study ichthyological engineering and four are studying fishery technology in what is called a beginning program of scholarships. The Ecuadorian Government is reported paying travel expenses and the USSR is paying educational and living expenses. . . .

. . . .**Estimated albacore minimum swimming speeds** at various fork lengths are similar to those of yellowfin tuna according to initial results of a study by R. Dotson, biological technician, La Jolla Laboratory, Southwest Fisheries Center, NMFS, NOAA. Pectoral lifting area and albacore buoyancy in sea water were calculated and speed computations showed rates of 57 cm/sec at 50 cm fork length and 44 cm/sec at 80 cm fork length according to the *Tuna Newsletter*. A full report of Dotson's results is now under review. . . .

. . . .**A prototype 50-ton, 33-foot buoy, designed to bolster** America's ocean and weather reporting system, has been anchored in the northeast Pacific, the National Oceanic and Atmospheric Administration reports. About 30 such buoys are planned over the next 5 years in areas where weather patterns are formed and storms are often spawned. Sensors on the tall-masted, disk-shaped buoys will measure wind speed and direction, barometric pressure, air temperature, surface wave height and period, and water temperature at seven depths. Data will be funnelled into the national weather forecasting system every 6 hours or, in special cases, in a matter of minutes. The buoys will largely compensate for the loss of Ocean Station Vessels which formerly collected such data. . . .

UNITED STATES
DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL MARINE FISHERIES SERVICE
SCIENTIFIC PUBLICATIONS STAFF
ROOM 450
1107 N.E. 45TH ST.
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